THE

ART OF TEACHING

YOUNG MINDS

TO

OBSERVE AND THINK.

FULLY ILLUSTRATED BY

SKETCHES

AND

NOTES OF LESSONS.

BY JOHN GILL,
NORMAL COLLEGE, CHELTENHAM,
Author of "Introductory Text Book to School Education."

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CONTENTS.

THE ART OF TEACHING.

CHAPTER I.

NATURE AND OBJECTS OF SCHOOL WORK.

EDUCATION, the physical, mental, moral and social discipline by which character is formed, is a work of the highest moment. From whatever point of view it is regarded its importance cannot be exaggerated. The future of every child, and consequently the future of society, which is but an aggregate of units, must depend on the early training of children. Give to this consideration its due weight, and it will follow that education deserves to have brought to its service the highest intelligence, the treasures of well stored and well disciplined minds, the most ardent devotion, and the most untiring energy of those who are engaged in it.

Every teacher should engage in his work with the conviction that all he does is educative. That, whether his intention be so or not, all that he does tends in some degree to form the character of those under his charge. This doubtless is true. But it is equally necessary for one who would secure the highest results that he should see clearly that the things he does, whether teaching, instruction, or discipline, are not themselves education. Take one instance out of many. Instruction is not education, education is not instruction. There cannot be instruction without education, there cannot be education without some sort of instruction. The two things are essentially distinct, yet inseparably connected. Education is an action of the mind itself and a result to the mind, of which instruction is but the instrument. Both receive illustration from food and digestion. By the latter process the former is assimilated by various organs of the body, and converted into vital

forces. So instruction may be regarded as aliment, and education the process which turns it into mental force and intellectual vigour.

It may be safely asserted that there cannot be instruction without some degree of education. Yet the truth remains, and ought to be thoroughly understood, that the degree of the educational result of instruction depends mainly on the method. It may be conceded that all teaching has a certain educational force, and must communicate some result to the character; but of two modes of teaching the educative force of one may be tenfold that of the other. For instance, let two persons instruct different classes in the same subject, say, the shape of the earth; one shall so treat his subject as to require no more effort than is necessary to clear apprehension of it; the other shall so marshal his facts and his illustrations, that his class will reason out inductively the subject for themselves. In this case the mental effort would be greater, the pleasure more intense, and consequently the educational result much more than in the other.

I. CONDITIONS OF SUCCESS. 1. *Desire to excel.* The first condition of success to a teacher is to have right motives in his work, and distinctly to fix in his mind the ends for which he should labour. Of course we eliminate all mercenary views. For though it is right that every one should consider well what he will get for his labour and skill, what sort of living he can secure, and what provision he can make for the future—though these may be among the motives which determine his choice of a profession, or his continuance in it—yet in the work itself there is room for the operation of other motives, and if he has a manly ambition, he will be more influenced by the desire to excel than by the amount of his pay. Even a stonebreaker or a scavenger, one would imagine, would be influenced by the desire to do his work well, although receiving for it an infinitesimal pittance.

2. *There must be a well considered aim or purpose.* Defects in school keeping may often be traced to the fact that the Master has exceedingly vague and misty notions of what he would be at, or to having very limited and mechanical conceptions of his work. A lesson to be said here, a bit of work to be superintended there, so much to be got through in the day, and the day's work done, having no

connection with other work going on elsewhere, and none with what has gone before, or is to follow, is a too common description of school work. In such circumstances it would be matter for surprise if there were not many defects and poor results. To be successful there must be an aim, a definite purpose; and this not merely for a day, or a week, or a year, but for the whole school life of the child. It should take up the child in the lowest class, and should provide for him courses of treatment and a progress that shall be as complete as the brief period, the irregular attendance, and the multiplicity of similar claims will allow.

3. *There can be no plan where there is no aim.* The importance of having a well-defined purpose is evident if we consider that where there is no *aim* there can be no *plan*. When there is a plan—even if the work is only manual—there are neatness, regularity and despatch. More is always done, and better done, with a plan than without one. This is true partly because no time is lost in settling what to do, partly because seeing what has to be done the efforts are better directed, partly because the worker being better able to mark his progress puts forth greater energy under the stimulus of accomplished work. Without a plan in school work, considered in relation to what has to be accomplished in the entire school life of the child, there come to be waste of time, misdirected energies, useless repetitions, and roundabout ways.

4. *Importance of the aim or purpose being a* right *one.* But not only must there be an aim or purpose, the end sought ought to be the right one. Nor is this a matter of little moment. Of two men, one accomplishes all that the other does and much more, because his end, while seemingly diverse, really includes or facilitates the accomplishment of all that is in the other's. A man who, to become expert in the rationale of arithmetical processes, and to become skilful in applying them, studies algebra, will better succeed in his object than if he had confined himself to arithmetic. One who wished to learn mensuration, geometrical drawing and perspective, with the best results to himself, would have a clearer insight into them and a better discipline from them if his plan embraced also geometry and trigonometry. So in school, one man's school is superior to another's in all the special matters for which the other

solely works, because he seeks a higher end than the other—an end which employs among his *means* the other's ends.

II. The Purpose of the School. 1. *Not a mechanical one.* The purpose of an elementary school is at first sight to teach reading, writing and arithmetic, with one or two other subjects which the circumstances of the case may make desirable or permit. And the schoolmaster might think that as the Inspector tests these, and the Government pays for them, therefore the teaching of these is his real work. But this would be a hasty decision. The mere ability to read, write, and calculate, is not in itself of that importance to the community as to warrant any expenditure out of the public funds to secure it. Any one who thinks this is the purpose of the school takes too low a view of its functions, and will secure lower results and receive a smaller share of Government pay than another with a higher view. A more important consideration is, that where a schoolmaster finds his work, as he thinks, in drilling in reading, writing and arithmetic, he cannot avoid producing other things than those for which he is aiming. In such a school will be found dulness, stupor, stupidity, pig-headedness, violent passions, mischief, rudeness, idleness—constituting an atmosphere and moral tone that are the worst possible for a child to live in. A mechanical routine finds no occupation for the higher faculties, gives birth to no high sentiments, and forms in the mind no ennobling principles. Schools in which a noble discipline of the intellect and will was to be secured were formerly termed "Free"—because their design was, through what was done in them, to set their scholars free from what was debasing, degrading, and enslaving in nature, manners and habits.

2. *Formation of character.* The *real* work of the elementary school is to form the character of the children, so that they may enter on the business and struggles of life not only with the prospect of advantage to themselves but of usefulness to society, that they may be able and willing to play wisely and well their part here, and to be in constant training for hereafter.

(*a*) *Distinction between education and instruction.* We may here recur again to the distinction between education and instruction, and to the use and import of the two terms,

teach and train. Education—a part only of which belongs to the school—is that use of the surroundings of a child, processes of instruction, and expedients of discipline, which puts the child in complete possession of all his faculties of body and mind, sets him on the road of improvement, and gifts him with such principles and habits as will secure his own individual welfare, and make him an active agent in promoting the well-being of others. In the words of Sir James Mackintosh, "Education embraces all those influences which go to form the character." Instruction, on the other hand, is one of the instruments for effecting this education. Its office is directly with the intellect, and indirectly with the will. With the intellect, its office is to place such things before it, or in its possession, as will enable it to develop itself and grow. Instruction furnishes the food which the intellect assimilates for its own nourishment and growth—this latter constituting so far education. Instruction gives knowledge; education—through the mode of obtaining and using—gives power and skill. With the will, by giving knowledge of such principles as should guide its decisions and actions.

(*b*) *Instrumental character of reading, writing and arithmetic.* The proper point of view also from which to regard the teaching and learning of reading, writing, arithmetic, and other subjects, is that of instruments to be employed in the formation of character. These are instruments, when acquired, by which much may be done in educating, and without which an individual is placed at great disadvantage for that purpose. But this is not our only point of view; for then we should be confined to the upper classes for their aid. Our point of view chiefly is that which regards them as instruments of education from the very first. Nor is this a trivial distinction. There are two ways of teaching and learning such things as these. There is the dogmatic and mechanical way—in which by dint of drill and repetition, accompanied, it may be, by harshness and blows, the children make a slow and painful acquisition, evince no liking for their tasks, and develop in disposition and temper ruggedness and excrescences. Then there is the educative and intelligent way—in which the child is recognised as having a mind gifted with wonderful powers, faculties and susceptibilities, in which by the use of right methods *these faculties are* brought into play, interest in their use

is excited, intelligence is awakened, and the child finds himself in possession not only of the special matter of his lessons, but of abilities, inclinations, and likings which give good promise for his future progress. For instance, suppose a teacher whose teaching is teaching (*i.e.* educative) to have a class of infants, and let us suppose that the children are at so early a stage as to have their attention fixed on such words as "cat," "sat," "mat" (a cat sat on a mat). Now his teaching being educative will secure the following things. First, the eye will be trained to distinguish and retain the words. Second, the child will gather from these and similar words by a sort of inductive process the powers of the letters a, t, c, s, and m. Third, these words will be so dealt with that ideas of the things themselves will be brought up in the mind. Fourth, some facts respecting them will be made to spring into the recollection. Fifth, a picture of a cat sitting on a mat, with accessories, will be formed in the mind. Sixth, by the manner, ingenious devices, and kindly spirit of the teacher, as well as by the exercise suiting their mental faculties, the children will have had pleasure in the exercise and will not be unwilling to engage in a similar one. Now in a lesson so conducted we have perception, judgment, conception, memory, imagination, and pleasurable emotion, where another method would simply have bored the children to death. Again, when teaching such subjects as grammar and arithmetic, the teacher may use them as moral forces. Inaccuracies of speech and erroneous results may be so regarded and dealt with daily as to make the children careful, accurate, and truthful, and so impress them into the habit that it would be positive misery for such children in their future life to be inaccurate, untruthful, or unfaithful.

(*c*) *Teaching and Training*. But perhaps the modern distinction between teaching and training best expresses the purpose of the elementary school and the relation of the schoolmaster's work thereto. To teach in its primary signification was to place something before a child which he was to learn to do. It made clear to him *what* he had to do. It showed him *how* to do it—and his efforts were superintended and his defects corrected until he was master of his work and had acquired more or less skill. Then—not till then—could he be said to be taught. Now "to *teach*" *is a* generic term—though many of its applications

are in the spirit of its primitive import. As a generic term it includes all the devices that are employed to fix the attention of the pupil during a lesson, all the means taken to solve or remove difficulties, or to enable him to master them, and all the ways that are pursued to bring him to exert his faculties until he has completely mastered the subject. "To train" comprehends teaching in its primary sense, and all the means taken to form the habits, manners, and principles of the scholar. It implies first, that in teaching, the pupil shall not be told what he can discover, nor that he shall simply master what his teacher provides for him when it is matter that he cannot discover, but shall be led to reflect upon it and so make it the means of obtaining something else for himself—*i.e.* that the knowledge acquired shall not be like dry sticks on a barren soil, but shall be like prolific seed in fertile land. Second, it implies that the pupil is put in possession of all the knowledge that is absolutely necessary for him; whether as regards his own health and vigour, bodily and mental, his relations and duties to his fellows, or his relations and duty to God. Thirdly, it implies that he is shown *how* to use this knowledge. And fourthly and chiefly, that in all possible cases the teacher shall see that he *does* as well as learns, that he acts as well as acquires, that he is wise as well as knowing. In fact by a series of doings on the part of the child under the instruction and correction of the teacher, to infix in his mind vital active principles, and to form him in all the habits that his best interests and relations require him to possess. To show the distinction which is sometimes made between teaching and training, let us take a simple instance as given by Mr. Stow. You tell a pupil to come to you. He obeys, but does it clumsily, annoys his neighbours by his mode of leaving the desk, and interrupts others by his noisy steps. To teach, says Mr. Stow, would be to point out what was improper, and why, and how to correct it. To train would be in addition to send him back to his place and to see that he came as you taught him.

III. Qualifications for the Teacher's Work. Among *personal qualifications* might be enumerated—self-control, geniality, good humour, strength of will, activity, manly character, not querulous, nor suspicious (and so on).

There are certain personal and acquired qualifications *which are indispensable* to one who would effect the purpose *of the school*. Let us briefly indicate a few.

1. *A well informed mind.* The work of the school presents itself, as we have seen, under two aspects, teaching and training—or looked at in their aims, the formation of the intelligence and will. Hence the formation of a teacher's own mind should be—

(*a*) A competent knowledge of the things he has to teach.

(*b*) A variety of knowledge, literary and scientific, to enable him to teach with freshness, to invest his subjects with attractions, to illustrate obscurities, and to enrich the minds of his pupils. Hence the teacher should always be adding to his stores.

(*c*) A knowledge of the nature of the intelligence and will, and of the relation of the instruments he employs and of his methods to their formation. In other words, he ought to have a knowledge of child mind—of its wonderful capacities—of the stages of its growth, and the powers manifested at each stage, and of the means and modes of cultivating each in its own sphere and to the highest point of perfection. Without such knowledge a teacher cannot be said to have even a rational conception of his work, and must ever be until he has it a mere empiric.

2. Proper feelings and convictions respecting his work. This will include

(*a*) *Love of children.*—Such a love as will make him earnestly desirous to benefit them and to fit them to encounter wisely and well the future that awaits them. Such as will lead him to study them, to inform himself of their characteristics, their idiosyncrasies, and their likings and dislikings. And such as will develop sympathy for them.

(*b*) *Love of his work as a profession.* The formation of character being the work of the teacher, that work may be called an art and the worker an artist. As much so as painting or sculpture. And surely one might look for in such an art—an art that deals with immortal mind—as much enthusiasm as that which deals in creations of fancy. Addison, speaking of education as an art and the educator as an artist, compares the mind to the beautiful image which is in the coarse block of marble before the sculptor touches it; and education to the art of bringing out that image. In reality the sculptor brings out of the marble a conception of his own, but the educator, if he succeeds, *brings out the* conception of God. The teacher who thus

regards his work "cannot fail to feel," says Laurie, "that he is engaged in an elevating, an inspiring, nay, more, *a creative task*. He is in truth, if he will but believe it, a kind of moral artist. He has a plastic work to do—the work of moulding the rude untutored nature of peasant and city boyhood into a shapely form. Nor will any one regard this as an exaggeration of the teacher's office who has had opportunities of contrasting the uncombed, untamed barbarian of civilisation, distinguished for his loose and insolent carriage, his lawless manner, licentious speech, and vagrant eye, with the same child sitting on the school-bench, well habited and clean, his manner subdued into fitness with the moral order around him, his tongue under a sense of law, his countenance suffused with awakening thought, his very body seeming to be invested with reason.

> From culture unexclusively bestowed
> Expect these mighty issues; from the pains
> And faithful cure of unambitious schools,
> Instructing simple childhood's ready ear—
> Thence look for these magnificent results.

"That such transformations are effected by the best schoolmasters, all know who have come into direct personal contact with educational agencies."

"Go thou and do likewise."

CHAPTER II.

SUCCESS IN TEACHING.

I. The first thing essential to success in teaching is to have a liking for it. He who is destitute of interest will fail to excite it. The amount of interest felt by the teacher is the measure of that in the class,—"Like begets like." The teacher's whole soul must be in his work. His heart must be given to it. Then his bright eye, beaming face, earnest tones, and deep sympathy, will develop corresponding phenomena in the children. Not that he should assume an interest *he does not* feel. But he should foster in himself

love for his work, and such strong attachment to children that his greatest earthly pleasure should be in teaching them, and in moulding their characters. That teacher is worthless as an educator whose whole soul is not in his work.

2. There must be faith in his work, and in children, if a teacher would be successful. There should be a firm conviction that the connection between real educational work and right results is as certain as the relation between cause and effect. There is often much to try this faith. Much work in school seems to be thrown away. After much labour, care, and painstaking, there seem to be no commensurate results. If so, it must be because the methods have been wrong. For the laws are as infallible in the world of mind as in the world of matter. To assert the contrary would be to say that God's inferior work is perfect, but that the higher domain is under the operation of imperfect laws. A child is dull, be it so; yet it possesses mind, which may be cultivated, all that is wanting is the key, the mistake is in not treating it in accordance with the laws of its being. Now in such a case faith is necessary or the teacher will make no effort, though he ought to be assured that in the case of even the dullest child, making intellectual effort and acquiring knowledge are always pleasant, unless there are peculiar circumstances to render it otherwise. If a teacher believes this then all he has to do is to discover and employ the right method; if he does not believe it he will become dispirited and tired of his work.

3. That there may be success in giving instruction in any subject, it is necessary to have a clear conception of its purpose. In relation to any subject where a broad view is taken of its objects, there will always be a general and a special purpose. The general purpose springs from the relation the subject has to some faculty or faculties of the mind, or to some particular want of the learner. The special purpose of a lesson comprises the imparting of some specific knowledge, or the attainment of some amount of skill. Thus in teaching geography, the general purpose would regard the influence which its right study should have on the mind now, and the advantage of such knowledge to the learner in later life. On the other hand, the special purpose of a single lesson should be that the pupils master that definite portion of the subject which forms the lesson. *Now, that there* may be efficient teaching these two must be

combined. The general purpose of the subject, and the special purpose of the lesson, must both be held in view to get the best educational result. The general purpose requires for its accomplishment some special mode of bringing into play the intellectual or moral faculties, which the subject is fitted to exercise, and *the method must change with a change of purpose.* For method in this relation is taking the pupils through such a series of observations, comparisons, imaginations, inventions, inductions or reasonings, as may be fitted to the age of the children, the special subject of instruction and the purpose to be effected. The accomplishment of the special purpose of a lesson will demand that a right use is made of questioning, illustrating, challenging, attending to answers, and such other devices of fixing and sustaining attention.

4. The subject of the lesson, and in its place, each point of the subject, should be placed as quickly and as distinctly as possible before the mind of the children. Generally this is best done by having prepared beforehand a few questions, each of which embraces one point of the lesson, and which are put in their turn as so many problems to be worked out. But whatever mode is adopted there ought to be no roundabout introduction under the false notion that it is the best way to excite interest. There is nothing gained either to teacher or children by beating about the bush. The more distinctly each topic is placed before the class, the better directed will be the efforts to master it. The children ought also to be distinctly conscious, when one division of a lesson is worked out, and another introduced; otherwise, while the teacher is advancing the pupils lag behind. It requires some skill in placing a topic before the class so that the exact conclusion is not anticipated, or the children may get the expression but not the thing. There are also two ways of presenting the same question. In one way the point shall be so put as to secure that the pupils pass through a process of induction and discovery; in the other it may be broadly stated, and the proof or illustration set forth. Which mode is adopted must depend generally on the intelligence of the class, but the former is the one best fitted to call out the energies of the children.

5. When a topic has been properly introduced, care must be taken that sufficient time is given for the pupil to apprehend *and retain it.* It is practically useless just to

touch upon a topic and then to leave it. As soon as a topic is brought forward the mind of the pupil settles upon it with the expectation of working at it; if then another is introduced before this is fairly wrought in confusion naturally follows, as the learner fails to distinguish clearly what belongs to one, and what to another. Hence no topic should be introduced unless pains and time are taken to illustrate and fix it. Where this is wanting, the pupils seeing that it is treated as of no importance will make no effort to retain it.

6. A "little and well" has long been recognised as an educational maxim in theory. The efficiency of a lesson to children is in inverse ratio to the multiplication of topics in it. Generally where one or two things attempted would command success, three or four would yield less, five or six still less, and generally the force of the discipline will diminish as the topics increase. Nothing but weakness in treatment and in effect, is the result of crowding many things into one lesson. It embarrasses the teacher, and is a temptation to hurry his pace beyond the capacity of his class to follow. It is often adopted as giving more to say. But this is a mistake; a limited area offers wider scope for efficient culture than a broader one. There is really less to say when the topics are many than when they are few. From the nature of the case there must be little said in a limited time where the things to be talked about are many. Besides, if but one or two things are attempted they may be placed in a variety of lights, or illustrated in a variety of ways, so that there will be a greater chance of reception by the class.

7. "Be simple and clear," is a necessary direction to one who would successfully teach. In order to the former the subject should be broken up into such portions as the class can receive at once. The difference in power between the teacher and pupil should be remembered. That which is easy to the teacher may be very difficult to the child. Relations or facts which the one may think too trivial to dwell upon may be absolutely necessary to the other. A father walking with his four-year-old child has to remember the difference in the size of their legs and their capacity of striding, and must accommodate his pace to that of his child.

In order to clearness, much talk must be avoided. Much

talk tends to obscurity. It has a bad influence over both teacher and children. The teacher who indulges it is apt to substitute sound for sense. He gets to imagine that the value of what he says is to be measured by the number of words that he employs. But the tendency of using many words is to the habit of seeing things indistinctly. It is almost certain that when a man uses many words in saying a thing his mind is hazy. And it is doubtless true that such a teacher places his class in a hazy atmosphere. It is as impossible for a child to see through a cloud of words as it is for it to discern objects through a dense fog.

8. Mental activity on the part of the children is the aim of good teaching, and is a test of its success. The degree of mental effort depends partly on the matter, partly on the method of the lesson. Sometimes the matter of a lesson may be of such difficulty as to require all the resources and skill of the teacher, by simplifying and illustrating, to place it within the grasp of the pupils. When it is so, one danger to be avoided is, its being lodged in the memory simply as verbal lore, without any real knowledge of it. Another is, not to estimate the difficulty beyond the reality, so as to take work on himself which they might perform. But most of the subjects, if wisely selected, will not contain matter too difficult to master. In this case the danger will be that the method does not help forward mental effort on the part of the taught. In these circumstances the teacher may be saved from mistakes if he remember and act on the following suggestions. As the pupils *must* be mentally active, his method must *force* and guide activity and thought. Hence it should vary with the special purpose and with the nature of the subject. When the subject admits of it, his standard should be to take them through the same processes of observation, reflection and thought, as were gone through either by himself when preparing the subject, or by those who first thought it out. "I am convinced," says Burke, "that the method of teaching which approaches most nearly to the method of investigation is incomparably the best; since, not content with serving up a few barren and lifeless truths, it leads to the stock on which they grew; it tends to set the learner himself on the track of invention, and to direct him into those paths in which the teacher has made his own discoveries." *A good test whether* a lesson excites thought is found in

the number of fresh thoughts started by the children themselves. In every good lesson there will be thoughts suggested by the children that were not even anticipated by the teacher. For good teaching has the same results on thought as living prolific roots in rich soil have in multiplying fruit; while poor teaching is as unproductive as dry, sapless, withered branches, in a sterile soil. Another test is, do the children get the desire and the modes of intellectual work. Teaching is valueless that does not prepare the pupil to go on without its aid, and it is equally so if it does not give him the desire to study and to gain knowledge.

9. Careful attention to his language and speech is requisite in a teacher. Distinctness is essential. For to a great extent the articulation of his pupils will be formed on his utterance. It is not in reading lessons alone that attention should be given to distinctness, for the style of the child's utterance is a growth until it becomes a habit, hence his model and practice ought to be constant. Again, distinctness is necessary to impressiveness. Feebleness and indistinctness tell at once of doubtfulness and uncertainty, and the consequence is that the ear of the pupil is not arrested. The sound falls without power to fix attention. But force and clearness speak of authority, decision, and the consciousness of knowing what you are saying. The result is that every child hears and attends. Mr. Bright has said that this is the secret of being listened to in a public assembly. Let every sound come out, and every word in all its parts be heard, and every one will be willing to attend.

Language should be correct as well as distinct. Pronunciation should be accurate. The vowel sounds should not be provincial; and the accents should be rightly distributed. Of these two the latter is the more easily acquired. In the case of the vowels it is more difficult, because the ear is already familiar with the provincial sounds, and any departure from them is thought to be wrong; the individual unconsciously setting up the speech of his district as the standard of correctness. There are but two ways in which a teacher can acquire correct pronunciation; mixing with well-educated people, and daily practice from a properly arranged book, till his ear is cultivated, and the habit *formed*. The same reason may be assigned for cultivating

correctness as for distinctness, that his pupils will fashion their pronunciation on his.

The language of teaching should be correct in grammar and expression. It is not by lessons in grammar that people learn to speak grammatically. This is a matter of use and imitation. Where children are accustomed to correct speech, they speak correctly. For their ear becomes familiar with certain forms, and they adopt the style of those with whom they associate. Of course, vulgar phraseology and slang must be avoided. These are often resorted to under the impression of being better understood. But this would be an insufficient ground, if a habit is by this means formed never to be eradicated. The teacher is not to descend to the level of his children's speech, but to raise theirs to his.

A teacher should strive to obtain a rich and copious vocabulary, that he may have at command the best words for his purpose. His stock should be practically inexhaustible, that he may suit himself to the several capacities of his children, and that he may never be at a loss to put the right word in the right place. Such a possession is only to be obtained from much reading of the best authors. But while copious he is not to be redundant. He is not to use more language than his purpose of securing mental activity requires, otherwise he obscures his pupils' vision. He must get into the habit of clear thinking. Clearness of thought is essential to brevity and clearness of expression. It is the want of precision of thought that stands in the way of saying just what needs to be said.

10. Teaching must be thorough. That it may be so a system of examination and repetition should pervade the lesson. "No lesson," says Stow, "is given till it is received." That is, till that which the teacher offers is mastered and becomes the property of the class the lesson is ineffective. Hence there must be examinative questions at every stage of the lesson to test the fulness of comprehension. That which has been put into children by question, statement, illustration and induction, must be questioned out of them. This will give them a better hold of it, and will secure some amount of thought upon it. It is also an effective mode of repetition. But other modes must be adopted. The same topic must be presented under a variety of illustration. *An exact* statement of anything that has been

given with the grounds assigned, should be required; and when it is wished to impress any statement or conclusion, it is well to have it simultaneously expressed.

At the end of the lesson the chief points should be questioned out, and briefly written on the black board. This has several advantages. It gives a connected outline of the lesson, and it aids the pupil to grasp the subject as a whole; hence it tends to give the power of continued thought. It is also a good aid to the memory, as these heads will be centres of thoughts and facts connected with them. And it serves the logical purpose of arrangement, and of enabling the pupils to discriminate between what is of primary and what is of secondary value.

CHAPTER III.

TEACHING IN RELATION TO THE PERIODS OF SCHOOL-LIFE.

It is almost an impossible thing to delineate, with anything like accuracy, that marvel—a boy, or girl, between the ages of 3 and 13. We shall not attempt it. But there are a few marked characteristics and well ascertained facts, that must be known and borne in mind by all who would teach so as to educate.

I. General Principles Relating to Child-Life.

1. There is no physical or mental faculty possessed by the boy of 13 which he did not possess in embryo at the age of 3. For education does not implant mental faculties, it does not create them, it only calls them forth and disciplines them. Hence it follows that if a boy of 13 is not in full possession of such faculties as belong to that age—if he is not *all* that a boy of that age *ought* to be, or *might* be, the fault is in his education, making proper allowance for natural differences.

2. Whatever powers a boy possesses at 13, have come to be exercised by him in a certain, definite, natural order of development. They were not, and they could not be, *all* simultaneously developed. Even where the mind exercises several powers on the same object—and this takes place even in early childhood in connection with the senses—it *does so in succession*—in rapid succession it may be—so

rapid that the succession is not marked—still in succession, and the order cannot be reversed. For instance, the child must observe before it can form ideas; and this also implies distinguishing and remembering, and it must both use its senses and possess ideas before it can imagine. Again, a child must hear words, and *watch* the speaker, and retain in idea what it hears and sees, before it can make an attempt to speak; and the perfect act only comes after many ineffective though not, therefore, useless attempts. This is the law; that of invariable succession—one coming before, because without it the next cannot follow. Hence it follows that if a child is to learn intelligently, attention must be given to the order in which the subjects come, and also the order in which the parts of a subject come.

3. But while the intellectual faculties follow a law of development, it would be a great mistake in conducting the education of the intellect, to treat the child as gifted with intelligence alone. A child has wonderful instincts; it is very emotional; it is joyous; it is not troubled by the future, and it has amazing facilities for enjoying the present; it is imitative; it is strongly sympathetic; and all these must be recognised and acted upon if we would educate even its intellect; otherwise the education will be wanting in warmth and harmony, and the child will be one-sided and dwarfed, and twisted, and knotty. It must be remembered that a child has a heart as well as a head; and it must be remembered that a child properly interested in any object before it, will exhibit itself—not some special aptitude and that only—but itself—a compound of many mental states, emotions, and actions.

4. It is a well ascertained fact that, depending on more or less obscure conditions of the brain, there are certain periods, or limits of age, when certain faculties are predominant, and when their culture can be better secured than at a later time. If the culture referred to is pressed on before the period, one of two things takes place—sometimes both occur—either the child is physically injured, or, which is the commoner result, it gains a present advantage at the expense of the future. It now expends so much brain force, as permanently to weaken that organ in subsequent years. Well, this being the law, it follows that the subjects to be acquired should not only be taken in a right order, *but at the right* time.

5. Whatever faculties have been developed under proper conditions and at proper times, admit and require further culture in the succeeding periods. So that while in each period supplying chiefly the special work of the period, yet there must be given sufficient exercise to the other powers —for that mind is the most vigorous which has duly exercised all the powers that have been developed. Just as the body is benefited more when all its limbs and muscles are cared for, than when exercise is only of one kind.

6. It follows that the master who selects his subjects or parts of subjects according to the period of child-life, and employs the methods most appropriate to the period, and who provides a succession of proper subjects and methods for his children, will make the best educator; he himself being what he should be.

II. Characteristics of the Infant Period. The children brought under instruction in school in the infant period range between the ages of three and seven. The former is the limit on one side because the power of reply does not admit of any profitable class instruction before that age, and the later limit is fixed because the brain is then complete in all its parts; and the child consequently can enter on the work of acquisition with a better hope of permanently retaining what it learns. It is called the period of development, because all the faculties or characteristics of the intelligence are putting in an appearance. This is done chiefly in connection with the senses, but not entirely so, because as the period advances the child has a wonderful faculty of creating scenes, and of living in a world of its own, although the materials of its creations have been furnished by the senses.

Between the limits thus assigned there are intermediate stages, depending very much on original endowment, but more on the previous surroundings of the little ones. For practical purposes the period may be subdivided into three, under fairly marked conditions, and with distinct aims and employments. Language is taken as the basis of division, because it is at once the expression and index of mental development; and further, because the possibility and efficiency of teaching depend materially on the power of reply.

The first sub-period commences at three, and continues for a year or a year and a half. A child at this age can,

observe, speak, and act. To observe implies that he can gather ideas by his senses. To act implies that he can conceive the action to be performed, and that he has the mastery of the organs by which it is executed. When the act is in obedience to a command, there is an indication that it can interpret the command, and that it has begun to associate acts with words. To speak implies the power to retain and recall ideas, as well as some power over the vocal organs. But we must not assume too much from this power of speech. Language has not yet become a sign. It is now but a transcript of their minds. The child first recalls the thing and then the word; and it does not yet use words as the instruments of its mental activity, these are its senses and ideas. Yet though not used for this purpose, language has some power of suggesting, where the words are familiar. It is requisite to remember also, that as language plays but a small part in their mental activities, the child's power to interpret what it observes is greater than its power of reply, and that to exact from it at this period a full answer, may be to demand a greater effort than is involved in recalling ideas.

The subjects suitable for this sub-period, are colour, form, and objects; moral lessons in connection with prints; and drawing common forms and the letters of the alphabet. The following rules must have attention in lessons in this period:—

1. The lesson must be disciplinary; and in order to this it must be judged rather by what the children *do* during its progress than by what they can *say* at its close.

2. The senses must be employed. They must examine by their eyes, ears, and hands. The teacher must take care not to hinder this by talking too much, or by giving them names or descriptive terms too soon.

3. The children must *discriminate.* Their senses must be so used, that things which would otherwise be looked at without being seen, may be really observed.

4. Ideas must be laid up for future use; hence, such ideas as the child can recall, as colours, or parts, or objects should be required.

5. Aid must be given to the children to express what they acquire, in simple sentences.

The SECOND SUB-PERIOD continues to the end of the sixth year. The *child* displays greater activity in the use of its

senses. Not only is it a recipient of impressions, not only does it form these impressions into ideas of its own, but, aware to some extent of its nascent powers, it puts forth independent and voluntary efforts on the objects around it. It has entered a more active phase of life, and it puts forth an aggressive force. The *conceptive faculty* partakes in the general advance. Feeling in itself a capacity to recall ideas, and finding that it can mimic life, it has a life of its own amidst the ideas it recalls. The child is found combining and arranging objects on some conception or plan of its own. It is also found investing things with qualities they do not possess. It personifies things. Anything will become to it a child or a pet animal, if there is but the least resemblance. It often talks to these imaginary beings; and it often regards an exceedingly ugly thing as if it was the perfection of beauty; simply because it is not the thing present to its senses, that is contemplated by its mind.

But the greatest advance is made on the side of language. Hitherto things have occupied its mind, and ideas of things have been the instruments of its mental workings. But the time comes when the child distinguishes a quality, and sets it apart, as an object of conception, from the thing itself. Now it finds that it cannot recall in idea a quality as readily as it can a thing, and it needs a word to become to it the sign of the quality, and having got the word, it recalls this, in order to recall the quality. Thus it has taken its first mental stride towards the region of pure intellect. Now, words as well as things play their part in the operations of its mind. Along with all this there is a marvellous growth of lingual power, and "Chatter-box" is a very appropriate name for the child.

In addition to the rules already given, the following must be observed in the lessons of this period:

1. Let the qualities in objects brought under the notice of the child be such as require minute observation; or, such as require experiment to make manifest, as the application of vinegar to chalk, or of hot water to tea. This will gratify its activity and give employment to its combining power.

2. Let there be much graphic description. Try to realize the child's fancies and aid it to form others. No lesson at this period should be without word-pictures, taking care that they are within the limits of the child's experience.

3. Give opportunities to the child to express as fully as it can the ideas it forms. Do not attempt to abbreviate your own speech by giving a word instead of a descriptive phrase or sentence; *e.g.*, say "We can see through water," rather than "water is pellucid."

4. Do not arbitrarily impose your own mode of expression for that of the child's. If it's is correct in form it is more likely to be life-like than yours.

The THIRD SUB-PERIOD ends at the age of seven. All the faculties of the child have put in an appearance, some in a fuller fashion, others in a more rudimentary way. The higher faculties do not yet work by signs, but great steps towards that consummation will soon be possible. As the senses are still active, and most of its mental furniture is still gathered by their agency, object lessons still form an important means in the child's culture. But the mind has now some stores of its own, and many of the impressions received from objects are modified and interpreted by what the child already knows. The fact being that nothing in nature is isolated, the child in its growing experience becomes aware that its knowledge of things wants completeness, so long as its impressions are not connected. But in addition to this, these stores give occasion for new powers to come into exercise, or powers of which hither-to there have been but glimpses. Not only are former impressions corrected, but the child gets the power of discerning relations among them, a power it could not have, had it not some mental stores. This prepares for another step, the child begins to see difference where it only saw similarity, and this opens the way for it to discern similarity where it had only seen difference. Here we have a growing power to discern relations amongst things, or amongst its own ideas. This growing power also gives it a higher use of language, a sure sign of a higher mental activity; *e.g.*, "A muff" had been a name given to a thing, soft, of a certain shape, into which to put the hands. Then the child makes a stride, and finds that a muff conceals the hands from the public gaze; with this advance has come the capacity for another, namely the transference of the term muff to something else which answers the same purpose, and strikes with the same appearance; as when a child looking out on a foggy morning, exclaimed "There is a muff over the trees." Besides this *growing power* of discerning relations, and of striking out

simple analogies, we have evidences also, though as yet but meagre, of the existence of the creative or inventive faculty, the imagination.

The rules for lessons at this period, besides those already given, are :—

1. Let such qualities of objects or structural adaptations in animals be sought as would escape attention.

2. Let there be a connection established between the qualities and uses of objects, and between the structure and habits of animals.

3. Let this connection be the subject of inference rather than of statement—the quality from the use, or the use from the quality; the structure from the habit, or the habit from the structure.

4. Let there be a constant use of analogies, and of analogical language. Speak for instance of the subtlety of the serpent, the cunning of the fox, the industry of the bee, the providence of the squirrel. Let such language be made vivid and real.

5. Let the lessons embrace scenes and actions, such as will not only exercise the conceptive and imaginative faculties, but such as will call forth sympathy, and require the exercise of moral judgment.

6. Close every lesson with a full description or statement. Let this be done sometimes elliptically, at others, by the children repeating the statements of the teachers.

7. In all teaching avoid excessive questioning on the one hand, and a constant flow of talk on the other. Questions must be such as will stimulate attention and effort, they must be such as will test intelligence, and they must be framed so as to secure a better hold of the subject. But as the power of listening to a statement and of gathering up its meaning is a valuable acquirement, there must be mixed with questioning judicious exposition.

In conducting lessons in the period of infancy, it is evident that one great principle must pervade the whole course, that of graduation; or of beginning with the simplest things and proceeding by degrees to those that are more difficult. At the same time the form must not be too systematic. There must be system. That which is given to-day must prepare for that to be given to-morrow, and should *make use of what* has been given before. At the same time *everything* approaching a scientific course must be avoided.

"Follow nature" is the best advice for the education of a child. The young mind is acted on from a variety of sources apparently without order, yet there is an order in its growth, and an interdependence among its faculties, so that strength and symmetry are the results. Let the teacher assist and be a co-worker with nature, and not try to supersede her by theoretic fancies and impracticable dogmas.

III. The Juvenile Period. In this there are two sub-periods; the junior or period of acquisition, the senior, or period of thought.

The junior period, or period of acquisition, extends from the age of seven to that of ten inclusive. It is marked by growth of the brain and of the body. Growth of brain is found to be highly favourable if not essential to the growth of memory. Hence this is a period of learning by heart. Memory being very strong, it is easy to acquire things, and easy to retain them. Especially is this the case with language, and now the child is increasing its word-stock, and is gaining in power of utterance. But a period of growth is also a period when the organs have a tendency to take a set. Hence it is not only easier to learn now, but in after years difficult to unlearn what is acquired in this period, whether by the brain or any other organ of the body.

During this period all the powers of the mind hitherto developed are found in constant activity, with the addition that memory by the aid of language is laying up material, the full value of which belongs to a later time. Fancy too becomes more chastened, and shades off into the higher imagination; yet not the highest, but that form which partakes of the nature of invention.

Our course then is clear. The scholar must be put into possession of the power to use books, and other instruments of acquiring knowledge. He must not get merely the art of reading aloud, he must be trained to gather from books what they contain. Here the teacher, by his methods, should explain, expound, and illustrate, but especially he should stimulate to reflect on what they read or acquire. But while *books*, rightly used, should be the chief medium of informing the mind, yet the forming of the mind must still be sought by the direct action of the teacher on the scholar; hence oral lessons must still form part of the school *course*. Nor will there be wanting suitable material. *Natural phenomena*, the simpler facts of physical geography

and a wider course of natural history, will be found admirably suited to the intelligence of the growing boy.

The SENIOR PERIOD, OR PERIOD OF THOUGHT, commences at the age of eleven. Boys are now frequently found in what has been termed a brown study. They seem for a moment to be lost. They are in a reverie. Their thoughts seem to turn inward. They seem to have an unconscious dissatisfaction with looseness and dogmatism. They want order and reasons. They begin to classify and to generalize. They try to understand or to discover, or they form hypotheses to account for the things that come before them. They are little theorists. They are groping after truth. In fact, they have entered on the period by which in intellect they are distinguished from the lower animals—they have begun to think.

The method of teaching at this time must take cognisance of this changing condition. There are still subjects to be acquired in which the method employed, will be that of stating the proposition, giving illustrations to make it intelligible, and adducing proofs of its truth, or the instances on which the proof rests. But there are other subjects in which a higher method may be pursued, and a better discipline obtained. On many subjects the pupil has stores in his mind which a judicious teacher will turn to account. In this case he will proceed by the method of induction, or that of from facts to principles by trial hypothesis, experiment, and legitimate inference. When by this means a principle has been obtained, the other method may be used. That is, the proposition may be formally enunciated, the illustrations which show its meaning given, and the instances from which it was inferred stated.

CHAPTER IV.

OBJECT LESSONS.

EARLY knowledge comes chiefly through the senses, and the power to interpret speech depends on what has thus been acquired. It may not be the fact, as some contend, that the mind is excited to activity by material impressions, *as there is reason* to conclude that it rather takes the initi-

ative, and by putting the bodily organs into motion, comes then into contact with material things, and has its attention drawn to them. For instance, light falling on the eyelid would not cause it to open, but the eyelid opened in obedience to a movement from the mind, the condition exists for light to stimulate attention.

But whatever the initiatory movement the fact is clear, that early mental operations, and the major part of subsequent ones are on materials furnished by the senses. The infant's first knowledge is obtained entirely in this way. By these inlets it lays up material on which the mind will work in later time. This is after a desultory fashion. The object lesson is intended to utilize this natural tendency, and to carry that on systematically which is going on continually.

The aims of object-lessons are not only to give systematic employment to the senses, but by the method of doing so, to teach the child how to observe, and to give him the habit of doing so well. Besides these, they aim at laying the basis of a habit of reflection. No object is isolated. No quality in an object is isolated. There are relations between the qualities of objects, and between objects themselves. There are also relations between objects and their uses. These relations are not always obvious, but they appear to careful observation and reflection; hence properly conducted the object-lesson trains to this habit. It also tends to extend the infant's knowledge of language, and enables it to use it definitely. Children are continually picking up language in a vague loose way, but the object-lesson counteracts this, by giving definite ideas, and requiring them to be expressed in clear terms. Thus the children get words to which they attach a definite signification.

But object-lessons may save the child from being overpowered by the sensual. For it is only as the mind is occupied by right material that it can draw aliment from the scenery in which it is placed, the common objects around it, or the ordinary occurrences that meet it. The great difference in the awakenings, activities, and enjoyments of any two or more minds from the same objects is due to the furnishings of the mind in relation to such objects. A geologist and a careless observer travelling over a rocky district would be in very different mental states. To one the country would be replete with life, interest, and objects of regard; his progress would be slow, and his journey

pleasant; to the other it would be a barren tract, wearisome to the flesh and irksome to the spirit, to be rapidly passed over. Why this difference? Not because to the one geology is an absorbing pursuit while to the other it has no charms, but simply because one has a furnished mind, which enables him to interpret appearances, and to find objects of curiosity and inquiry where the other sees no meaning. The one mind from its previous knowledge is all activity, the other from the want of it is all a blank. And this is true, not only in the case supposed, but in relation to objects of which they are equally ignorant. The one accustomed to observe would be active from habit, while the other would remain quiescent; in a word, one mind would be replete with movement, the other would be a stagnant pool.

Much that young children possess, they can be scarcely said to help, for their attention is arrested without their consent. Activity from within, and impression from without, leaves the child no choice but to learn. But a time comes, as may be inferred from what has just been said, when the solicitations are as it were weaker, because they come to a mind not apt by previous awakening and attention, as a child or a man might be placed all his days amid beautiful scenery in which thousands of objects of interest occur, and yet remain ignorant from want of a quickened mind. Hence the value of object-lessons, not merely in giving the habit of observing, but in laying up in the mind that material without which objects cannot be regarded with interest or even with intelligence. Place a newly discovered plant before two men, one ignorant of botany, the other familiar with it. The plant would be regarded in very different ways. From one it might get a passing glance, its colour, form and scent might be noticed; by the other it would be eagerly examined. Interest is there, because intelligence is there, and intelligence is there because of previous knowledge and habits.

NOTES OF OBJECT-LESSONS.

1.—A Brick.

1. *Shape.* Show a brick. Used to build with. How placed? How many surfaces has it? Give other things with six flat surfaces. What call them? Cubical. Measure

the width and thickness, what is the difference? Notice the shape of each surface. *Oblong* Measure the length, how many inches? Could you alter the shape? How? What does the bricklayer do when a brick is too large?

2. *Material*. Of what made? Of what colour is clay? Clays are of various colours. What is the colour of the brick? What has been done to change its colour?

3. *Making*. Did you ever watch a brick made? Where? In what state was the clay at first? How made smooth? How is the brick shaped? What do you call that in which it is shaped? A mould. How is it the brick does not fall in pieces? What do we call clay? Adhesive. When the bricks are taken from the mould where are they placed? How are they placed? What is that for? The air to get to them to carry off the moisture.

4. *How made hard?* Where are they placed? What is a kiln? How are the bricks piled in the kiln? Where is the fire kindled? What does the heat do?

2.—Slate.

1. Slate is a mineral. Name other minerals. It is obtained from a quarry. Describe and compare with a mine. It is obtained in large masses or blocks, but is easily separable into thin plates, or leaves, foliated. Compare with mica.

2. Slate often seen. Where? Used for roofing houses. What qualities needed? It must not be too heavy, yet must resist rain. Sometimes moss is found growing on roofing slate. Moss requires moisture, that must come from the slate. What does that show? The slate is porous.

How discover at the quarry whether the slate is porous or not? Take a cubical mass, weigh it, put it into water all night. Take it out, and what do to it? Wipe it dry, then weigh it. If heavier, what then?

3. Slate used for writing on. What sort of surface? How made so? What sort of a mark the pencil makes? What if the pencil made a scratch? Slate can be easily cleaned, hence cheap. How clean the slate? Sometimes the slate is greasy, and then hard to write on. How do they become greasy? What is the shape of the school slate? Oblong and flat. How many corners? Sometimes placed in a frame. What to prevent? When a slate is broken, what *kind of a fracture?* Compare with glass.

4. Ask for other uses, as for mantel-shelves, and grave stones. What qualities fit it for these uses?

3.—Sugar.

1. Show some white crushed sugar and some salt. How tell one from the other? Perhaps by the eye, certainly by the taste. Show the fatal consequences that have sometimes resulted from trusting to the eye alone, as in taking oxalic acid in mistake for Epsom salts.

2. *Granulous.* Bruise some, it is reduced to small parts. Call them *grains.* Mention other things made up of grains.

3. *Soluble.* Put a little in a glass, and pour in water. Stir. It separates into smaller parts, at length it disappears. What has become of it? Taste the water. It is sweet, then the sugar must be there. How small the parts must be. So small that the eye cannot see them, yet the tongue can taste them.

4. *Penetration.* How is it separable into such small parts? What has it done to the water? Diffused itself throughout or penetrated. It thus penetrates that some things may be used as food by being made palatable. Refer also to jam, and show that by this property it helps to preserve fruits.

5. *Nutritious.* Often mixed with food. Tell that it helps to keep up the heat of the body.

4.—An Apple.

1. *Show an apple.* Elicit that it is a fruit. Grows on trees. How is the tree known? By its bark, leaves, blossom. Of apples there are great varieties as to size, appearance, and taste. Compare shape with that of a pear, and of an orange. Notice changes in appearance as to size and colour during growth.

2. *Taste.* Sometimes sour; if so, what? Unripe, unpleasant, hurtful. But when ripe has a sweetish and pleasant taste. Very wholesome. Compare the tastes of varieties, and of these with pear and plum. Could you tell an apple by its taste?

3. *Stalk.* How is the apple fastened to the tree? Where? Notice the thickness of the stalk and its toughness. Compare the strength of the stalk and of the branch

with the weight of the fruit. Show also that it is exposed to wind. Show also that all that the apple is in size has passed through the stalk. What is the inference? When the apple falls from the tree, how is it accounted for?

4. *Skin.* Observe the differences in the skins of the various kinds of apples. Some coarse and thick, some fine, smooth, and thin. Why this difference? Notice also the use of the skin. What would happen if there was no skin? The fruit is exposed to the sun, to rain and to dust; the result would be the juice would evaporate; the rain would soften it, and the dust would render it unfit to eat, hence the skin a protection.

5. *Pulp.* Refer to the difference between a bruised apple and a sound one. When an apple is cut what is observed? Where is the juice found? Why is it in cells? Refer to cider, what has happened to the juice?

5.—Coal.

I. Introduction. A piece of coal to be shown to bring out obvious qualities, as black, some coal glossy, other coal soils the hand. Compare with chalk. Slightly adhesive.

II. Varieties of Coal. 1. *Hardness.* Coal is often seen in big lumps. How made smaller? Coal is broken by blows. Elicit that some kinds require *heavier* and *more* blows than others. These you must hit and hit again. Not here and there, but on the same place till it falls in pieces. Elicit that some coal is hard to break when struck in one direction, but easy in another. Explain this to be due to what is called cleavage. Give examples of other things with the same quality. Elicit that some coal is very easily broken. What are such things called? Require instances of brittle things.

2. *Durability.* Observe that some kinds of coal burn away much more quickly than other kinds. Some leave a reddish ash, others a grey. Some leave much ash, others little. Infer that other things beside cheapness must be considered when buying coal.

III. Facts connected with Combustion. 1. *Smoke.* If we put coal on the fire, what do we soon see? Where does it come from? Draw attention to the quantity, if it did not go up the chimney, it would soon fill the room. But it was *all in the coal.* How has it been set free? Heat drove

it out. Heat expands things to which it is applied. Smoke is a part of coal expanded by heat.

2. *Soot.* Build a chimney of new bricks. Place a fire under, so that smoke may ascend. After a time the bricks are encrusted with soot. This a deposit from the smoke, when cooled by the bricks. Soot is an element of coal. Notice some of its qualities and uses.

3. *Flame.* Look again at the coal on the fire. The thick brown smoke is soon followed by a bluish grey smoke, and this is followed by flame. Elicit by reference to coal-gas, that the heat sets free a gas that takes flame. Draw attention to the colours of the flames, to what owing?

4. *Heat.* Observe that heat passes from the fire in all directions. Notice that its intensity decreases with the distance. How is that? Compare with light and shadows. Draw attention also to the coal in the midst of the fire. Some of it is red, other parts white and bright. State that it depends on the intensity of the heat. Ask what is the appearance of the fire when air is sent in by the bellows, so as to elicit that white heat is more intense than red.

5. *Tar.* Observe the fluid which bubbles when some coal is burning, this called coal-tar. Notice also that some coal while burning forms a strong crust—this is called *caking.*

6.—A Bell.

1. *Show a bell.* Its *name.* Its parts, cup, clapper, handle. Ring it. Gives forth a sound clear and pleasant.

2. *The cup.* What is it like? Compare with a tea-cup and a thimble. Ask for flowers of this shape. What name is given them because of their shape? What is the cup? Hollow. Which is the widest part? What is the edge? Circular. Let it be felt. Hard, cold, smooth. Notice the material of which it is made. Should be strong, not easily broken, and give forth sound. Notice the effect of a crack in the bell on the sound.

3. *The clapper.* What it is? Where fastened. How fastened? Why so? What is there at the end? A knob. What shape? Why this shape? If it touched the side of the bell in more points than one what would be the effect?

4. *The handle.* Of what made? Why not made of one *piece with the bell?* Take a glass and hold it by the upper

part and strike it, then place it on the palm of the hand and strike it, what is the difference in sound? What is the shape of the handle? Why that shape?

5. *Uses of bells.* Large bells send forth loud sounds, heard a long way, hence used to call people to church. Where are they placed? What sort of a place is a belfry? Why is it high up? Sometimes the church bell rings to tell us that a person has just died. Called the passing-bell. Sometimes it is rung to tell there is going to be a burial. At other times there is a merry peal. When? Notice bells in houses. Where placed? How hung? How are the wires connected? When are such bells rung? Refer to the school bell, to the bells at large work-shops, and at the railway stations, and the use in each case.

7.—Clouds.

1. *Appearances of clouds.* Clouds high above our heads, sometimes much higher than at other times. Sometimes clouds can be seen above clouds with large spaces between. Very different in shape. Often change. Differ in size. Sometimes very small. Sometimes very large, covering miles of space. Sometimes very thin, sometimes very thick. Give the terms dense, thick, heavy, lowering, dark. And again, light, fleecy, in long streaks, red, and so on. How pleasant on a summer's eve to watch the ever-varying clouds!

2. *Uses of clouds.* Clouds are always in motion. How is this? They are carried along by the wind. They show us the rate of the wind. Sometimes the motion is scarcely perceptible, at others they move on very rapidly. What do they carry? We get from them rain, snow, and hail. They receive moisture from the ocean, and convey it over the land, dropping it as they go. What would happen if this were not? Refer to the rain and snow that fall in hilly lands. How it sinks through the soil. And thus we get springs and rivers. Could we without clouds? Did you ever watch the shadow of a cloud on a summer's day as it passed over the landscape? What large masses of cloud are often seen in summer! They do not cover the sky. We can see much blue. These clouds stop the sun's rays, and thus screen from the heat.

8.—Water.

1. *Exhibit some.* Elicit that it is clear, bright, sparkling, pellucid and flowing. It forms into drops. What is the shape of a drop? Look at rain just going to drop from a window frame, what is the shape of that drop?

2. Have a greasy plate, drop some water on it. It collects into globules. Put some on a clean slate, it spreads and adheres to the slate. Hence infer grease repels water. Refer to water rolling off a duck's back, and to birds in rain not getting wet. How is this? If your hands are greasy, how do you get them clean?

3. Drop some water on paper. It penetrates. It has spread over the paper, and entered it. What does this show? It has separated into very small parts. Notice the importance of this quality. Beeause it separates into very small parts, and penetrates, it sinks through soil, and so we get wells and springs. By means also of this quality it *softens*, and so when washing we can remove dirt. Because it softens and penetrates, it helps to make vegetables grow; by dissolving their food, and making it small enough to be sucked up by the fine tubular roots.

4. Observe water at rest. It has a smooth level surface, because the small parts flow freely among each other. Fill a dish with water to the brim, place a shilling on a level with the water on one side, while the eye of a child is placed at the other side. How much of it can be seen? How is this?

5. Place a shilling in a basin, so that the children cannot see it. Pour in water; it appears in sight to some. Take a ruler and put it into the basin. How does it look?

9.—Milk.

1. Compare it with water as to drops, flowing, transparency and taste. Elicit that it is obtained chiefly from cows, and that when first obtained it is warm.

2. *Cream.* After standing some time what comes to the top? Infer that cream is lighter than milk, or it would not float. Illustrate by cork in water. Ask for the colour of the cream, and of the milk when the cream is taken off.

3. *Use of milk.* Taken as food. By whom chiefly?

Very nutritious; as it is the sole food of babies it might be inferred that it contains all that the body needs. State that this is the fact. It is also easily digested, or turned into blood.

4. *Modes of cooking it.* State that it ought not to boil, but be removed from the fire just before boiling. Elicit that when boiling a thick portion swells up, and if the pan is too small it runs over. Heat expands it. Refer to other modes of using it, and the effect of union with eggs.

5. Ask for milk products. Butter. Cheese.

6. Give the proverb, "It is vain to cry over spilled milk," and ask for the lesson it teaches.

10.—Trees.

1. *Our lesson is to be on trees.* Name some. What a variety! Some are very tall, others very low, some have very thick trunks, others very slender. Some trunks are covered with rough bark, others with smooth. Ask for specimens of each sort.

2. *Let us look at the branches.* They are up over head, so that we can walk under them. They form a shade. Look how they are placed. Some point upward like the poplar, some slantingly, some horizontally, some droopingly. Give instances, and endeavour by graphic description to excite vivid ideas. Look how the branches spring from the trunk. First there are thick ones, then somewhat thinner ones spring from these, then other thinner ones from these, and so they go on, until at length we have very thin ones called twigs.

3. *Leaves.* When are the leaves on the trees? When do they come? How do they look then? When do they fall? What change takes place before they fall? Some have large leaves, some small, some round, some oval, some triangular. Some have an even edge, some a notched one, some are scooped, and so on. In every case let the children give instances, and when possible the teacher be provided with specimens. Why are there such differences? Variety yields pleasure, uniformity and sameness are dull. State also that leaves help us to distinguish trees.

4. *Flowers.* When does the blossom appear? Of what is the blossom the forerunner in the apple, pear, plum and

other trees. What sort of blossom has the chestnut? Ask for others.

11.—Root of Tree.

1. *Its use to the stability of the tree.* Notice the breadth of base occupied by some trees. Observe also the roots of trees in exposed situations, where the tree would be likely to be blown down. What takes place? Refer to *tall* trees and to low ones, to trees that throw out many long branches, and to others less bushy. Which require the broadest base? Is it so. Give instances, as the elm, and the oak. Show that there is compensation in some instances in the depth to which the root pierces. Infer that the provision in each case is exactly adapted to the need.

2. *Use to the sustenance of the tree.* The root not only holds the tree firmly, it is like a number of mouths. Much of the material that forms the substance of the tree is drawn from the soil. What facts show this? What is the difference between poor and rich soil? In what form does it enter the root? How is it absorbed? How conveyed? Draw attention to the spongioles and to the tubular fibres.

3. *How is it that roots do not decay?* Elicit that wood left in the ground rots. Refer to the means taken to preserve the foot of a post placed in the ground. How is it that roots do not rot? Compare with the body. After death this decays or rots, but in life not. Infer that life preserves. Apply to roots.

12.—Trunk and Branches of a Tree.

1. *Strong and tough.* To elicit these qualities refer to the weight of the branches, if not strong, the trunk would rend or tear, if not tough it would break. The trunk is like a great pillar upholding the tree.

2. *Bark.* Draw attention to its appearance and thickness in different trees. In some trees thick, in others thin. Some bark rough, other bark smooth. Elicit that thin bark is usually smooth, and the thick rough. Why is it so? What is the use of the bark? What flows under it? If this was exposed what would happen? It would evaporate, or it would get clogged with dust. Hence bark protects the sap and therefore the life.

3. *Branches.* Compare the point where they spring from the trunk, or from the parent branch, with their tips. It is much thicker and stronger. Why? Refer to the *weight* of the branch to bring out the necessity of strength. Refer to the mass to show the quantity of nourishment required. Infer the wider the base, the more sap can flow.

13.—Soap.

1. *Show varieties of soap.* Differ in colour. Differ in hardness. Some soft when bought. How? This increases the weight. Dry soap most economical. Refer to fancy and scented soaps.

2. *Solubility.* What is it used for? What is used with it? Why is water required? Water softens. What happens to the soap when rubbed in water? Soap is soluble in water, becomes very small, forms a lather, gives to the water a whitish appearance.

3. *Adhesive.* When the hands are covered with lather they slide easily over each other. How do the hands feel when the soap has dried on them? How does the soap help us to clean the skin? It and the dirt adhere, and then can be easily laved off.

4. *Show a piece of soap,* show also the ingredients of which it is made. How have these been formed into that? Give some notion of the process.

14.—Finger-nails.

1. *Position.* At the end of the fingers. How many? Why placed there? Bring out that nail is hard, and that the ends of the fingers are soft, pulpy. Show also that we use the tips of the fingers to feel with. Nail is hard, protects, acts as a buttress, aids in picking up small things, as needles and pins.

2. *Appearance.* Smooth, glossy, colour varies. At the root white, in the body pink. What makes it so? At the end, whitish. Shape is curved, fitted to the finger, bent in at the sides.

3. *Growth.* How inserted? Often the skin peels off at the place of insertion, and is sometimes the cause of pain. Nails grow. They have to be pared. Notice that long nails are unsightly, and as they are sharp, if you accidentally

struck any one, they might cut them. Observe that the part we pare projects, and is without feeling. What does that show? God's goodness. If we cut the nail where it is attached to the skin the pain is very acute. People call it cutting to the quick. The outside of the nail may be scraped without giving pain. Comes off then in fine shavings.

4. Cleanliness. Dust easily gathers betwixt the part that projects and the finger; this gets moistened by perspiration; it gives the ends a blackened appearance. What does that show? That nail is semi-transparent. Nails must be cleaned. How? If the nails are not kept clean and pared the person is considered dirty and careless.

15.—Tea-pot.

1. *Show teapot.* What is it? Why called tea-pot? Not because made of tea, but because tea is made in it. Compare with tin kettle. Ask for other instances as cream jug, gas pipe, pen knife. When tea is to be made what is put first into the pot? Why heat the pot first? What sort of water is put on the tea? How long does it remain before it is poured forth? How is that?

2. *Spout.* What is the spout for? What other things they know so called? What the spout is? Hollow. How it curves, and narrows near the mouth. Notice the shape of the lip. How is it the leaves do not come out? Show the strainer. Draw attention to the place where the spout is inserted. Why near the bottom? Show that if placed higher the tea would run over the top. Notice the top of the spout, above the level of the teapot. What would happen if it were lower than it?

3. *Lid.* What is its use? Keeps out dust, keeps in steam. Notice the hole in the lid, lets in the air. Notice the knob. What is it for?

4. *Handle.* Why have one? Of what material is it made? Why? How is it fastened?

16.—Glass.

I. Used for windows. Name the subject of the lesson. Where have they seen it? How fitted for windows?

1. *Windows are to admit light.* This is done by means of

glass. Some panes are transparent, we can see things beyond them. Some panes are not transparent, yet they admit light. Instances, ground glass, thick glass.

2. *Windows are to exclude rain and draughts.* As glass admits light but not air, light must be thinner than air.

II. USED FOR DRINKING AND OTHER VESSELS. Such vessels must be clean. Glass can be easily cleaned and polished. It is smooth, the lip does not like a rough edge. It is used for bottles because it keeps out air. Sometimes medicines are put into coloured bottles. How is that?

III SHAPES. Glass is found in various forms. Sometimes flat as in panes and mirrors, sometimes in goblets, sometimes moulded, &c. How thus produced? Show by experiment that glass can be melted. Describe blow-pipe operations.

IV. BRITTLE. Notice that glass is easily broken, especially by heat. How does heat break glass? Give examples of expansion by heat. Infer that the application of heat to glass must be gradual.

17.—HAIR-BRUSH.

1. *Show one.* What is it? Why called *hair* brush? Let the materials be named—wood, bristles, wire; and the parts—handle, stock, bristles.

2. *How are the bristles fastened?* What is the use of the wire? Why use wire? Elicit its qualities.

3. *What is the use of the brush?*—To separate and clean the hair. Hence the bristles must be sufficiently stiff, yet not too rigid. Why? Suppose them soft like threads, what then?

4. *Show that the bristles are smooth.* What if they were rough? Dirt would stick to them and they could not be so easily cleaned.

5. *When the brush is used the bristles bend, and return to their position.* These qualities how named? Give other instances of flexible and elastic things. If the bristles were not flexible they might tear the skin, if not elastic, when bent they would so remain, and thus become useless.

6. *The length of the bristles.* Why equal? We thus get a surface the whole of which can be used. Single bristles have little force; hence the advantage of united action, one sustaining another.

7. *Notice veneer.* What fastened by? Why use glue?

18.—Sheep's Wool.

I. Clothing to the sheep. As compared with some animals the sheep's skin is comparatively thin. Elicit that sheep spend much of their lives in fields, hence require warm clothing. It furnishes clothing for man. How? Hence it is useful both to sheep and men.

II. Shearing. Wool cut off. When? Why not in winter? Before the wool is cut off it must be of a certain length, and if it remain on too long, it becomes unfit for man's use. What does this show of man? That he is expected to observe, to find out things for himself. Sheep-shearing formerly a time of rejoicing. Nabal and David.

> "The housewife waits to roll her fleecy store,
> With all her gay-dressed maids awaiting round."

III. Qualities of Wool. 1. *Absorbent*, takes in moisture. Hence useful in flannel.

2. *Soft and flexible.* Hence adapted to our skin and to the movements of our bodies.

3. *Tough.* Had it been brittle it would have needed constant renewal; but being tough it is durable.

4. *Fibrous.* Where often worn? Next to the skin. The fibres produce a gentle friction, and act as a healthy stimulus to the skin.

5. *A bad conductor of heat.* Illustrate what this is. Infer that woollen clothing is useful in preventing the escape of heat from the body.

19.—Salt.

1. *Comparison.* Show lump sugar and salt. What is this? And this? Can we be certain? How may we? Can you give instances of people being deceived by trusting to the eye only?

2. *Flavouring.* What is the name given to the taste of salt? Saline. What is the use of this taste? Draw attention to the taste of a potatoe boiled without salt, and eaten without salt. Compare with a potato when salt is used. Give other instances. Infer that salt makes some things more agreeable to the taste.

3. *Colour.* Salt is white. Why should it be this

colour? Show that the value of salt depends on its purity. Being white it can be seen if it is clean.

4. *Soluble.* Dissolve some in water, it cannot be seen. Each drop of water tastes salt, then there must be salt in each drop. How small the parts. How numberless. Show that, because salt is soluble, it can be used in preserving meat, it penetrates the pores betwen the fibres. Ask for instances.

5. *Fusible.* Apply a piece to flame. What happens? What use is this? Give the anecdote of the discovery of glazing earthenware.

20.—FLOWERS.

I. VARIETY. 1. *Where seen?* Some in fields, some in hedgerows, some on mossy banks, some on hill-side, some in woods, some in water-courses; these termed wild flowers. Ask for the school song—

"Flowers, wild wood flowers."

Others are found in gardens; these are cared for—cultivated. Exhibit beauties that were not manifested before. Compare with children in a school.

2. *Differences in flowers.* Ask for examples so as to get differences in size, shape, colour, positions on stems. Bring out that some send forth odours, some agreeable, some disagreeable. Some have no scents, only beauty; some possess both. Ask for the verse—

"Down in a green and shady bed."

II. TIME OF FLOWERING.

1. *Show some.* They could not have been had a month ago. Elicit that each month has its own kinds, so that we might form a calendar of the year with flowers. When do you find the snowdrop? In what month does the crocus appear? When do you look for the primrose or the daffodil?

2. *Notice their opening and closing.* Some open early in the morning, others later; some at noon, others as night draws on. Then also their times of closing are constant with the same flowers, but vary with different sorts. Some people can tell the time of day by the opening and closing of flowers. Hence they have a flower clock.

III. THE PARTS. By examination of varieties let the children discover that there are four parts. Arranged round the stem in circles called whorls. Inner ones opposite the openings of the outer ones. Draw attention and give names. Calyx and sepals; corolla and petals; stamen, pistils, and the parts. Show the carpels, ovary, style, and stigma.

IV. STALKS. Let attention be drawn to their colour in different kinds; to their thickness, and to their strength in relation to the weight of the flower; compare the daisy with the rose. If there were an alteration in the force of gravity, what changes would be required in the stalks of plants?

21.—TEA-CUP.

1. *Exhibit one.* What is this? How do you tell a cup? By its shape. What is the shape of this? Show a mug. They are both cups. What is their difference? A mug is cylindrical, a tea cup is vaulted. What is the colour? How do you know the shape and colour? What do you use? Then by rightly using our eyes we learn. Could a blind boy learn these things? He could learn the shape but not the colour.

2. *Tap it.* Tap a cracked cup and a whole one sharply. What do you perceive? A sound. Is there any difference? Yes, one is a clear ringing sound, the other jars. Now what did you employ to learn that? Then we learn by our ears.

3. *Touch it.* It is cold, hard, smooth. These are learnt by touch, we use the points of our fingers. Can we discern these things by means of any other parts?

4. *Brittle.* Suppose that I did not know whether it could be easily broken, how might I find out? That would be an experiment; but still I should have to use what? Now, if I were to make that experiment, what should I learn? That it would easily break; then I must be careful.

5. *Shape.* Can I alter its shape? Only by breaking it. Then how could it be made into this shape? It is now hard and brittle, and cannot be altered without breaking, then it cannot always have been so. It must once have been soft, and not brittle. Show the materials of which cups are made.

22.—Coal-gas.

I. Gas escaping from a burner.

1. *Expansion and elasticity.* Draw attention to the pipe by which the gas is brought to the burner. Trace it. Show that some parts are vertical, others horizontal. Infer that the gas *ascends* the vertical pipe. Open the top. Soon the gas, even though only a small portion escapes, is found in every part of the room. Then it has diffused itself; there has been expansion. That which was confined in the pipe has spread in every direction. This is elasticity.

2. *Intermingling.* What was in the room before the gas was turned on? Is it still there? Animals cannot live without air; but we live, then air must still be present. Then the gas has intermingled with the air, like milk in tea or water.

3. *Odour.* How do we know its presence? By the smell. It is a disagreeable odour, and a very good thing too, for gas is very explosive.

II. Gas in flame.

1. *Inflammable.* It takes flame easily. Give other things that do so, compare with things that will burn, but are difficult to ignite.

2. *How flame is possible.* The gas is elastic. It spreads, and issues through the tap in a thin stream. The holes very fine, so that not much comes out at once.

3. *Air necessary.* How is it the flame does not pass through the tap and burn the gas in the pipe? Give facts to show that the presence of air is necessary to its combustion.

23.—Horn.

1. *Where found.* Ask for the animals that have them? Where do the horns grow? In what respects are these animals alike? Where do they feed? How do they obtain their food? How do they feed? What such animals are called?

2. *Shape, position, and use.* Draw attention to the *shape* generally. Thick at the base and gradually tapering. Ask for varieties. Notice also the *position.* At the front of the head, often pointing obliquely upwards. Elicit their use. What have they observed or heard in respect of bulls, cows, or goats?

3. *How adapted for defence.* They are hollow, why not solid? If solid they would be more liable to snap, or to fracture. They would also be heavier, and thus would weary without being stronger. Point out also the advantages of a broad base and a tapering form in an instrument of attack.

4. *Uses to man.*

(*a*) *When horn is boiled it becomes a jelly.* This jelly is semi-transparent. Exhibit a piece of horn plate. How was it made so? Infer that when a jelly it was poured out and spread, and that as it cooled it became solid, or tenacious. It was formerly used for windows. "Now we see through a glass darkly."

(*b*) *Implements.* Infer that in a state of jelly it may receive any form, thus we obtain handles in knives, combs, and other things.

24.—A Book.

I. The Inside.

1. *Introduction.* What is in my hand? We shall have a lesson on a book; and we shall first take the inside.

2. *Leaves.* What is this? A leaf. What are several? Leaves. What is the difference in spelling? What is the difference in meaning? Ask for other instances. Ask for other things called leaves? How came these to be called leaves? Refer to the plants, on the leaves of which people formerly wrote. So that when they changed the thing they kept the name.

3. *Pages.* What do we call the side of a leaf? How many pages in a leaf? How many in four? In ten? How many leaves in twenty-four pages? On which leaf will the twenty-fifth page be? On which side of the leaf will the thirteenth page be?

4. *Sheets and size.* Draw out distinction between a leaf and a sheet. A sheet is folded into leaves. Lead the class to infer that the larger the leaf, the fewer the leaves out of a sheet. Hence the terms, folio, quarto, octavo, and others, descriptive of the sizes of books.

5. *Letters.* Letters of several kinds—capitals, small, italics, sometimes ornamental letters, sometimes black ones, and so on. For the letters we want type, ink, and presses.

II. The binding.

1. *The sewing.* How are the sheets fastened? Find

the threads. Show that they are in the middle of sheets, or half-sheets, and are passed round strings.

2. *Boards.* How fastened on? By the strings, round which the threads are placed. What is the use of boards? Preserve the leaves from turning up, and from wearing away.

3. *Covering.* Cloth, leather. Why used? How fastened?

4. *Number of persons employed.* By referring to all the materials employed, and to the processes, show that a very large number of people must be employed before we could have a book.

25.—An Orange.

1. *A fruit.* Compare kinds of fruit. They differ in purpose. Some are for sustenance, others for refreshment. To which does the orange belong? Hence often a suitable gift to the sick.

2. *Colour.* Show yellow and red. Have a palette. Mix the two. Compare with the orange. Hence this gives name to a colour. Tell that colours so formed are not simple colours.

3. *Shape.* Compare with ball. Let the difference be seen. Make clear the difference of diameters. Do this by means of a piece of wire pushed through the centre. Take sections of the orange, and get out the shapes of their flat surfaces.

4. *Rind.* It is thick as compared with the apple. How so? What is the rind for? It secretes a preserving fluid. But it also protects from evaporation and dust. Now by reference to the places in which it grows, show that it is exposed to more intense heat than the apple, hence thicker rind. Show also that it is tough, does not crack. It is flexible; can be nicely peeled. Refer again to its secretion of oil. By means of it the juice is retained, and the orange kept fresh. How?

5. *Juice.* Sweet and refreshing. Where found? Cut an orange. The juice is in little cells. Why? Compare with honey when in a mass and when in the cells of the honey comb. Compare also with the juice of apples in quantity, and in the cells of the apples. Infer that by this arrangement fermentation is prevented.

6. *Inner skin.* Covers completely each distinct part. What is this for?

26.—Grass.

I. Introduction. Refer to the aspect given to the earth's surface by grass. How would it look without it? But grass enamels it. To enamel is to beautify, or to preserve, in both senses true of grass. Draw attention to the varieties of grass—120 kinds in England only. Varieties of colour.

II. Description. Exhibit a complete specimen. 1. *Root.* Brown, rough, fine threads; by bending show that it is flexible and rough. Not easy to take out of the ground by pulling. When taken out and the soil shaken off, how do they appear?

2. *Stem.* It springs from a single seed; compare with a pea. The stem is *hollow* In some varieties it is *jointed*, and some grasses take root from these joints. The stem is flexible: it bends without breaking. It is tough, not easily broken.

3. *Leaves.* Spear-shaped. Narrow, long, tapering and pointed. Termed a blade, that is thin and flat. Compare blade of knife. Some leaves have sharp edges, they would cut the skin.

4. *Arrangement of the leaves.* Spread out a complete specimen on a sheet of paper, and show the arrangement; the third blade above the first, the fifth above the third, the fourth above the second. Give examples of a similar and of a different arrangement in the leaves of other plants.

5. *Flower and seed.* At the top of the stem, the latter looking like chaff. Its shape, oval. Very many on each shoot. Why so? That it may spread. What a large number of animals feed on grass!

III. Lessons to be learnt from grass.

1. It occupies the lowest position, is often trodden upon, yet always looks pleasant.

2. It yields and bends before the slightest rebuke of the wind.

3. Mow it, and it yields more shoots. Thus returns good for evil.

4. Some grasses when trodden send forth a rich perfume.

27.—Clock-face.

I. The term,—face. 1. *Refer to human face.* How expressive of inward states,—joy, sorrow. An angry child shows anger in the face. Where do you see the smile and merry laugh? The face is an index. It tells us what is going on within.

2. *Face means outside.* Show by examples this use of the word. Elicit that outside implies an *inside.* Now take both meanings and show that the clock-face is an index on the outside of what is going on inside.

3. *Dial.* The face of a clock is often termed a dial. How so? The word was first applied to the disk on which the shadow of the style was thrown in sunlight. By this people knew the time of day.

II. The hour and minute marks.

1. *Hour divisions.* How many? What are they? Equal. Why are they equal? How much of the time marked on the clock-face is one honr? How much is it of a day? Why not have clocks of twenty-four hours?

2. *Minute divisions.* How many are there in the space between two figures? How many in all? How much are five minutes of one hour? How much of an hour is one minute? In how many ways can you express five minutes?

III. The fingers.

1. *Their length.* One is longer than the other. Why this difference? One points to the figures, the other points to the small marks, and these are at different distances.

2. *Their motions.* How much does one exceed the other? How often does the big finger go round while the little finger goes once?

IV. The shape. Why circular? Would any other shape do as well? What do the fingers describe? What are they? Fingers are radii, and from a common centre describe two circles.

28.—A Plum.

I. Formation of the pulp.

1. *Parts of a plum.* What are the parts? Skin, pulp, stone or kernel. Which do you eat? All but the skin and kernel.

2. *Pulp.* Contains juice. Cut one carefully, and there

is a little on the knife, just enough to moisten it. Now squeeze it. Much juice flows out. The juice is preserved in cells. Compare with apples. How did it get there? Show necessity of tubes. Let a child look at the pulp through a microscope, and tell what it sees. It will discern fine tubes through which the juice flows into the cells.

II. OFFICE OF THE PULP.

1. *Sustenance.* Draw out that when a plum is unripe the pulp sticks to the stone or shell. How is this? Let the shell be broken. What is inside? What is its use? By illustration show that the pulp is sustenance to the kernel.

2. *Shell porous.* Show that the shell is porous, and that the juice flows through its pores till the fruit is ripe.

3. *Ripe plum.* Take a ripe plum. Show that the pulp separates very easily from the stone.

III. VARIETIES OF PLUMS.

Some small, some large. Some have a fine bloom on them. Very pleasant to eat, but too many produce sickness.

29.—A STREET-LAMP.

I. ITS PARTS AND POSITION. Draw one on the blackboard.

1. *The post.* What it is? Often a little broader at the base. Why? It is *hollow* because it encloses a pipe. It is *high.* Why? That its light may be diffused over a wider space, and that children may not meddle with it.

2. *The lamp.* Of *glass;* this lets light through, but prevents the wind blowing the flame about; hence it can shine with a steady flame.

3. *The frame.* Material is iron. This does not burn, and occupies little space. Yet is strong. At the bottom are two perforated doors. Why doors? How get to the burner? How turn on the gas? Why are the doors perforated? Show the necessity of air. Point out the *chimney.* Where? Why necessary? Show that soot blackens, and that burnt air must escape.

II. THE LIGHT.

1. *Gas.* Where is it from? How is it conveyed? What property does that show in the gas?

2. *Flame.* How is the gas turned on and off? Where

is the tap? How does the man light it? What is the shape of the flame? Fan-like. By what contrivance is this shape produced?

III. ADVANTAGES.

1. Contrast a town lit with gas with a village or a country-side, where there is not any. What are the inconveniences? What the dangers?

2 Show that there is greater safety to property when gas-lamps stand at short distances.

30.—DANDELION.

1. *Where found.* Often found in large numbers in fields, by the side, and also on the road-side. They have a bright yellow colour, and give a pretty appearance to the country roads. Whence did it get its name?

2. *The root.* What is its shape? How does it differ from that of a carrot? In what is it like? What is often done with the root? Dried, roasted, ground, and mixed with coffee.

3. *The stem.* What it is as compared with that of colts-foot? Much thicker. It is also hollow. What do boys sometimes make of it? Break the stem,—What sort of a juice? What does it do to the hands?

4. *The flower.* Its colour. When open what shape? What does it do soon after we pull it up? What are the petals most like? The number of a buttercup may be told at a glance, but we have to take care and time in counting those of a dandelion. What sort of a calyx has it? Can you see the calyx when the dandelion is open? How is that?

5. *Seeds.* When do they come? How are they arranged? They form a ball. Each seed is attached to a downy stalk. What is the use of this? How often seen floating in the air! How is it they are borne so easily along? When children find them they often puff them and count. What do they want to know? What would you say of this?

CHAPTER V.

LESSONS ON ANIMALS.

1. Lessons on animals extend the range, and widen the purpose of object lessons. Precluded in most part from having the animal in presence, and confined to such make-shift substitutes as pictures and stuffed specimens, there are not the *direct* means of cultivating observation, as in the case of an object before the class. In this there is no loss. For more is sought and more is possible in lessons on animals than the culture of observation merely.

2. A threefold culture, exclusive of their moral purpose, is sought by these lessons. (*a*) They offer a wide range of facts for observation; facts that are admirably adapted to extend and strengthen the habit which the object lesson has begun. Colour, size, shape, covering—its structure, qualities and uses, actions, food, modes of getting food, and other things of like kind, give the material for this purpose. (*b*) They offer also an extensive array of facts for the culture of the conceptive faculty and fancy. Facts and anecdotes abound illustrative of instincts, dispositions, habits, and intelligence. These presented by graphic picturing will not only call the higher powers of conception and fancy into play, but will excite the desire and furnish the power of a more widely extended observation. (*c*) They offer also the means of cultivating the sense of relation and of incipient judgment. The marked instances of resemblance amidst diversity, the opportunities of working out analogies, the relations that abound, and the adaptation of structure to habits, food and circumstances, furnish the means and suggest the propriety of this higher culture. It will be found, too, that such things are not only not beyond children's powers, but that they are interesting and stimulating in the highest degree.

3. Lessons on animals should begin with those the children have the opportunity of observing; for then only will they be able to carry out in practice the habit it is intended to form. Besides the discovery in familiar animals of things that had escaped notice, by gratifying the emotions of surprise and wonder, will stimulate and direct the feeling of *curiosity*. Such animals, too, when once known, will become

types by which the distant and strange may be made intelligible. But lessons need not be confined to them. Those belonging to other lands may be taken which give rich material for the exercise of the higher faculties, or where the adaptations are obvious, and not beyond the power of the children to realize.

4. When a print is used, whether it should be shown at once, or not, must depend on the immediate purpose. In the case of a familiar animal, no object is saved by withholding the picture; and in such a case the print should be employed chiefly for the purpose of introduction, and as a reference during the lesson. Interest should not be frittered away by common-place remarks on what the picture presents, but such points should be carefully worked out that it cannot exhibit. But in the case of an unknown animal, it may be well first to give a graphic description of it before showing the print. This will exercise the conceptive faculty, and will give the opportunity of correcting erroneous impressions. When the print is shown, and the question put, "Of what is this a picture?" it should be followed up at once by "How do you know?" "What makes you say so?" This will at once compel them to fix attention on those points by which they recognize an animal, and will show them the necessity of careful observation and of accurate description.

5. In conducting the lesson, require such things that they have observed; tell things that will make them curious to observe, and give them the power to do so see that they have material for the exercise of judgment, and let their inferences be inductions from facts, rising spontaneously to their own minds, and not prompted by the teacher; be graphic, and thus endeavour to give ideas and things rather than words; and close every lesson by a description, embodying the chief facts that have been brought out.

6. The moral purpose of the lesson should ever be present to the mind. Feelings of admiration awakened by surpassing skill, manifested in innumerable particulars, will tend to awaken feelings of kindness towards the inferior animals, and will go far to prevent acts of thoughtlessness, cruelty and tyranny to them.

NOTES OF LESSONS ON ANIMALS.

31.—The Cat.

I. Form and appearance.

Compare its form with some other animals, so as to bring out its beauty. Refer to the graceful movements of a young kitten. Draw attention to the glossy skin, and the pains the cat takes to keep it clean. What a lesson for you! Will you be outdone by a cat?

II. Skin. 1. *Covered with fur.* What kind of covering? Compare with the hair of a dog. Why has the cat fur? Show that the dog is more active, runs about more. Notice that cats do not like to go into the rain. Refer to a duck. How is it that its feathers do not get wet? Point out oil-cells. Refer to other animals with a similar provision. The cat has no such cells, hence its fur would soon get wet, and the cat be injured.

2. *Refer to stroking the skin.* Sometimes the cat makes a sudden attack on you. Why? You have gently stroked her, why should she attack you? Refer to electric condition produced by friction. Use the experiment of cloth and glass. State that an electric spark may sometimes be obtained from the tip of a cat's ear.

III. Head. 1. *Whiskers.* Where placed? What is their use? Refer to the cat's habit of rambling at night, and creeping through holes. Suppose a cat to try a hole that was too small. It might stick fast, and neither get through nor draw back. What a catastrophe! Now look at the whiskers. How are they placed? Measure them from tip to tip. Which would require the larger hole, its body or its whiskers, supposing these not to be bent? Then if the whiskers pass the body will.

2. *Eyes. Power of expanding and contracting.* How many have observed a cat's eyes. They often open them very wide. When? They sometimes become very small. What is the shape of the pupil then? A thin slit. Thus the cat can dilate and contract its eyes? Why has it this power? Refer again to its rambling at night! Did you ever meet a cat in the dark? How were its eyes? Tell that this power enables it to see in a very feeble light.

3. *Mouth.* What has it in its mouth? Did you ever touch its tongue? How did it feel? What are its teeth?

It can kill mice and birds, and it likes to eat flesh, therefore its teeth are sharp and strong.

4. *Ears.* You see a cat lying before the fire. Scratch the table, so that you can only just hear it. What does the cat do? Sometimes it lifts its head. What does it do with its ears? Erects them, makes them stand up quite stiff? Can you move your ears?

IV. FEET. 1. *Cushions.* Observe how softly the cat treads. It runs, but you hear no footfall. Suppose a mouse or a bird in sight. It creeps, it must make no noise. How is this brought about? Refer also to its jumping from great heights. The cushion breaks the shock. How?

2. *Claws.* They are very sharp. Kept in a sheath. It can protrude and retract them. Keeps them covered when not in use. Why? Refer to their use. They must be kept sharp; if not in a sheath they would wear, and become blunt.

32.—THE CAT'S HABITS.

1. *Clean.* It may often be observed cleaning its face with its paws, and brushing its fur coat.

2. *Damp and moisture.* Does not like these. Will not wet its feet, but its liking for fish sometimes overcomes this repugnance.

3. *Warmth.* Likes to lie in a warm place in the day-time, but to ramble at night.

4. *Purring.* Makes a peculiar noise when pleased. Likes to be taken notice of; rubs itself against your legs, or against a chair or table.

5. *Fear.* Erects its tail, which becomes very thick and swollen, when frightened or angry.

6. *Likings.* It loves places rather than persons. Has been known to return to an old dwelling, but after some days to forsake it, not seeing the old familiar faces. It is easily provoked, and will scratch the hand that has just fed it. But it paws very gently any young child that fondles it frequently.

7. *Prey.* Stealthily approaches it. Lurks patiently for hours at the hole of a rat or mouse.

33.—LION-ANT.

I. GENERAL DESCRIPTION. Our lesson is to be on the Lion-Ant. It is very likely that none of you have seen it,

yet you may tell me something about it. *You* think because it is called an ant it is an insect. Well, it is an insect, though it is not like an ant. What is an insect? Refer to a fly, or a bee, or a wasp, for the things by which an insect is known. Give the size of the lion-ant? About that of a wood-louse. Any one show me that size? Its colour is greyish, with black spots.

II. COMPENSATION. *How it obtains its food.* There is something else you can tell me. It is an insect, and that it may live, it must have *food.* Some animals eat other animals. Name some. Well, the lion-ant feeds on other insects. What must be done before it can feed on them? As Mrs. Glass said of the hare, " before you cook it, catch it." Now, I have something very curious to tell you. The lion-ant cannot move forwards, it can only move backwards. How, then, can it catch its prey? Refer to the spider. It lives on flies; the fly has wings, but the spider has none. How does it catch flies? So that it has something instead, or, as we may say, something to compensate for the want of wings. What would you call a spider's web? If you want to catch a thing unawares you set a trap. The spider's web is a trap for flies. Now the lion-ant makes a trap, and so it has something to make up for the want of power to run forwards.

III. THE SKILFUL CONTRIVER. 1. *How it makes the trap.* It makes a trap in the ground. The trap is a hole like this in shape, and size. (Show a piece of paper rolled up like a funnel, and inverted, and make clear that the narrow part is uppermost. Give the size, the depth two inches, and the larger diameter two inches.) How can it make such a hole as that? What do people need who dig wells or foundations? They have to loosen the soil and to shovel it away. The lion-ant must do both. Now, listen, the lion-ant's head is flat, just like a spade and fastened to its head are two feelers, a quarter of an inch long, and made like spades. Its tail is like the point of this pencil. With its tail it digs the hole. What must its tail be? It must be sharp and strong.

2. *Now we will watch it.* It has found a nice place. Where, think you? Refer to rain. Rain would fill the hole and drown the lion-ant. Then it must be where rain *cannot reach* it. Look! It puts its tail into the ground *and runs.* How? State that it makes a ring, then another

inside of that, until all the soil of the mouth is loosened. What then? It darts its head and spade-feelers in and jerks out the soil. So it goes on till the trap is made.

IV. THE WARY WATCHER. *How it catches its prey.* State that the lion-ant hides itself in the sand at the bottom of its den. What is it waiting for? Suppose an insect to fall in, but not near the lion-ant. It tries to escape. Can it? Elicit that from the shape of the trap it will find it hard to climb. Yet, as the lion-ant cannot run after it—Why not?—it may make its escape. Now state that the lion-ant jerks after it a shower of sand, and so brings it back.

V. THE CLEAN HOUSEKEEPER. When it has feasted on the juices, it casts the carcass out of the trap at least six inches away.

VI. THE WONDERFUL CHANGE. The lion-ant becomes a dragon-fly, and is famous as a wasp-killer.

34.—THE HONEY BEE.

I. INSECT. 1. *Exhibit a bee—a preserved specimen.* Draw attention to wings and legs. How many legs on each side? How many wings?

2. *Look at the bee without its legs and wings.* It has a head and its body is in two parts; so that in all there are three parts—head, thorax, and abdomen.

(*a*) *Head.* Show that like ourselves it can hear, see, taste, and smell. These by organs in its head. By reference to its antennæ show that it can also touch, like we can with the ends of our fingers. Hence it learns by its head many things necessary for it to know. How does its knowledge differ from ours? It has no means of retaining it. It only wants it for present purposes.

(*b*) *Thorax.* To this are fastened its legs and wings. These are instruments of movement. So that the motions of the bee are governed by the thorax. Where, then, should you take hold of a bee so that it may not sting you?

(*c*) *Abdomen.* This is the part in which its food is converted into nutriment. Notice the two tubes running down the sides for the admission and conveyance of air.

3. *External Skeleton.* How is the bee kept in shape? Refer to ourselves. Our bones form an internal skeleton, the bee has an external skeleton. Describe it. Give the term insect, and examine on preceding points.

II. HABITS. Structural adaptations. 1. *Honey-gatherer.* Refer to bees on flowers. How do they settle? What are they doing? If not able to tell, refer to their hive, and what is found there. How did it get there? Where did the bees get it from?

(*a*) *Its tongue.* Refer to honey-suckle. The honey is deep down, yet the bee gets it. How? Bring out that it has a long tongue. Describe it, and its four joints. What are these for? Where does it put its tongue when not in use? Nicely folded up and put out of its way. Describe the lateral opening of the mouth. Deduce a lesson to put away things tidily after using them.

(*b*) *Honey-bag.* Elicit that the bee does not carry home every drop of honey as soon as it gets it? What would that be? A sad waste of time. It gathers a little here and a little there. How does it keep it? It must have a place to store it. Describe the honey-bag situate in its mouth.

2. *Pollen, or bee-bread.* Describe pollen. Where have you seen it? Elicit that it easily comes off the flower, and sticks to the finger. Infer that when a bee gets into a flower the pollen will stick to it. Compare with a lad's head in a flour-bag. Now draw attention to the bee's legs covered with little hairs, by means of these it can brush off the pollen.

State that it mixes pollen with honey and eats it. State also that the honey-gatherer gathers pollen for the workers at home. How does it carry it? Describe the "baskets" in the two hind legs. Tell the children to notice bees going into their hives. Many have their hind legs laden with yellow pollen.

Bees are tidy, industrious, careful, and generous. One works for the other.

35.—THE WASP.

I. DESCRIPTION. Draw this out. How do they distinguish a wasp from a bee. Notice its elegant shape, its yellow rings, its head, eyes, and antennæ; also its thorax, legs, and wings; also its abdomen, long, slender, elegant; the female furnished with a sting.

II. STRUCTURE AND HABITS. 1. *Wings.* Compare as to wings beetles, crickets, dragon-fly, and bee. State that *insects are* distinguished by their wings. The wasp, bee,

and ant are alike. The wing is a membrane. It has arteries, veins, nerves, absorbents, and cellular tissue. These insects termed *hymenoptera*. State that its wings help respiration as well as flight.

2. *Jaws*. Draw attention to the nest. The material is paper. This paper has been made from woody fibre, often cut off a dry window-frame. How is this done? Point out that there are two contrivances. (*a*) Serrated jaws, which are very strong, by which it separates the fibre and masticates it. (*b*) It also secretes a sticky fluid, by the aid of which it forms the masticated fibre into a pulp. Give other instances of powerful jaws, as in the burying-beetle.

3. *Nest*. (*a*) *Its situation*. Point out or elicit that wasps' nests are found in various situations; infer that wasps are of different kinds. The common wasp makes its nest under ground. It is globular, twelve inches in diameter. What is its circumference? How does it make the hole? Describe this and the two passages by which the wasps enter or leave the nest. The passages vary in length—from six inches to two feet. The passage is zigzag. Describe the contrivance of arches and pillars, placed concentrically to preserve the nest from destruction by rain.

(*b*) *Its use*. It is their home. Here wasps are born, live, work, and die. Like other insects, its first stage is an egg, its next a grub. Unlike the grubs of many insects which find their food where the egg was laid, or like others which seek their food, the grub of the wasp has its food brought to it. Hence the nest is needed for the grub.

4. *Food*. By reference to facts which children may observe, show that wasps feed on flesh. Point out also that they collect the juices of fruit in bags. and that they carry insects in their jaws to the grubs. Infer also that the stayers at home are fed by the outside workers.

36.—A Duck.

I. Description. Let us try to make a picture of a duck. It is from twenty to twenty-four inches in length, and from thirty to thirty-six inches round. Its body is not a cob, like that of a hen, but is longer and flatter. Its neck is long and curved. At the front of its head is a bill, broad and flat. Its feet are short, and its toes webbed. Its legs are placed far back. What is it covered with?

II. Structure and habits.

1. *Shape.* Point out that habits often depend on food. Compare the hen and the duck. The one scratches the ground for its food, hence has strong claws; the other often gets its food out of the water. Hence it is often found on water. The shape of its body fitted for floating on water.

2. *How preserved from the effects of water.* Get from the class the effects of water. Chilling and softening. Draw attention to the means to keep warm. What would be an effective provision? Show the down especially on the exposed parts. How does this help? But water softens as well as chills. How kept off? Put some water on a greasy plate. What occurs? Infer that this would be a good contrivance to keep off water where things were exposed. Now give the facts of the smooth polished feathers and the oil-sacs. Here we have a special contrivance for a special need.

3. *Motions.* Refer to its movements on land. They are awkward and clumsy—called waddling. How is this? The legs are placed far back. Now point out its motions on water—graceful. Show adaptation of the body. Notice also the position of the legs. Show how much this assists in diving. Draw also attention to the webbed feet. Why are they webbed? Show that a broader surface strikes the water, therefore a better fulcrum, and a greater onward force.

4. *Food.* It lives on small fish, insects, and worms. Its food where? Often far below the surface, hence it has a long neck, power to dive, and to breathe under water. Compare its bill with those of the swallow and the hen. Show how each is adapted for getting its own food. Draw attention to the fringe. Food should be clean, but the duck often draws worms out of the mud. They are held in the beak and washed. The fringe keeps the mud out of the mouth.

37.—A Pig. A Lesson for Little Ones.

1. A pig lives in a sty. This is often very dirty, hence any filthy place called a sty. A pig will sometimes lie in the dirt, hence we sometimes say of dirty boys, as filthy as a pig.

2. Pigs really like a clean bed, but they soon dirty it. *Such a bed as* theirs would make us very wretched. Com-

pare the pig's skin with man's. It is thick. How can they tell? It is so thick that the prickly straw does not hurt it, nor does the wet make it cold. Its skin is just as thick as it needs for its home. Compare with the horse, cow, and elephant.

3. Pigs eat things that would otherwise be waste. Potato peelings and the leavings of the dinner-table. Such living cheap. Hence it does not cost much to keep a pig. When the pig is killed what then? We get pork, ham, bacon, and lard. Thus we have turned what we cannot eat into good food.

4. Pigs make a curious noise when they want anything. It is called a grunt. But they can make a much louder one, and they do when being killed.

5. Did you ever look at a pig's foot? Is it like that of a horse or that of a sheep? Did you ever see a pig rise to its feet? On which legs did it get up first?

6. If you were near a sty that you could not see, would you know it? How would you find out?

7. The farmer gets manure from its sty. But for itself it is of no use till it is killed. Sambo said, "It is the only gentleman in England." What did he mean?

38.—Aard-Vark.

1. Show a picture of one. It looks like a pig. It has a curious name. Aard-vark. Aard means earth, vark means hog. Then its name means—?

2. Where would you expect it to live? Yes, it lives in the earth. Tell me some other animals that live in the earth. Moles and rabbits. These animals make their own holes or dwellings. How do they? What are they called? Burrowing animals.

3. The aard-vark makes a hole in the earth. Men want tools, but burrowing animals use none. The aard-vark uses its claws. It has four toes, with strong hard nails on its fore-feet. By these it scrapes the earth.

4. It feeds on termite ants. These make hills so strong that a waggon-wheel will scarcely break them. The aard-vark pierces them with its claws. Having made a hole wide enough it puts its snout in, and protrudes its tongue. Its tongue is very long, and covered with a sticky moisture. The ants stick to it, like sugar would on yours.

5. It is difficult to catch. Men watch its holes, and another digs with a spade. It is *cooked* when caught.

39.—Dog.

I. *Description.*

Draw attention to its shape as compared with the cat. Elicit that there are many kinds of dogs. Elicit the kind of covering it has, and the varieties of covering in different kinds. Elicit that its ears are pendent, its nose cold in health, that it can easily turn its head, the muscles of its neck being very numerous. Its spine very flexible, so that it is unfit to carry burdens.

II. *Habits.*

Elicit that it proceeds by jerks and bounds when running. It laps when drinking. How is the tongue adapted to this? It likes to bury bones; for this purpose it burrows with its nose. In attacking its prey, it does not approach stealthily like a cat, but openly and boldly. Not so cleanly as the cat.

III. *Domestication.*

1. It is the friend of man. It attaches itself to him. It is faithful to its master, and careless of strangers. Give anecdotes.

2. It has the faculty of imitation. Proof of this in his bark. Wild dogs howl, but never bark. Dogs bark in imitation of man's speech.

3. It is intelligent and teachable. Refer to blind beggar's dogs. To common instances of "fetch and carry." To instances of dogs taught to shut a door, or to abstain from touching meat till permission has been given. To their imitation of death at the word of command. To their purchases of food, taking a penny and receiving its value.

4. Sensible of praise and blame. Wags its tail when pleased or praised. Runs away with its tail between its legs when blamed. Has it a conscience?

40.—Spider.

1. Where seen? In houses. These called *house-spiders.* Also seen in gardens. Called *garden-spiders.* Ask for other kinds. Some very large, others very small. Sometimes called an insect. But this not correct. Notice the *differences* between a fly and a spider. Examine on the

marks of an insect. How many pairs of legs has a spider? Its body is in how many parts? Spiders can hear and smell.

2. *Its web.* Of what name? Fine threads curiously interwoven. How are the threads made? Where is the material from? What is it like? Compare with treacle and water. Water falls in drops, treacle will run into a fine thread. The spider's threads are sticky like treacle. How is it the spiders's thread does not break when a spider hangs to it? Would a thread of treacle hold the spider's weight? Point out that toffee when hot is soft, but as it cools it hardens. Compare with the spider's thread. State that each thread we see is made up of thousands of finer ones.

3. Describe the web of garden spider. Circles outer and inner. What call this arrangement? Give other instances. Notice also the radii. Elicit that the concentric threads are more elastic than the radii, and are sticky and transparent. The radii are opaque—not very elastic, but strong.

4. The spider *spins* its web. What for? The spider is—where? Hidden. A fly touches the web, the spider feels the vibration, and rushes out on its hapless victim.

41.—Elephant.

I. *Adaptation of legs to weight.* Give its size eight to ten feet high, and its weight three to five tons. The children to give weight in lbs. Illustrate by tons of coal. What would such a weight require? Refer to heavy buildings, to portico in front of church or other edifice, to roof of cathedral. How held up? Look at the elephant's legs. Why thick? Why straight? Suppose they were crooked, what then?

II. *Adaptation for food.* Compare a baby, boy, and man. Which requires most food? Compare other animals. Then infer that generally the larger the animal the more food it will require. The elephant is the largest of land animals; needs much food. Where, then, should it live? Refer to the prolific vegetation of its habitats.

"Scratch the soil and it yields a crop."

It is also found in forests, and eats the thin shoots. For

urging its way through the trees it needs a thick skin. It needs protection also for its eyes. How is this met?

III. *Adaptation to drink.* It lives in a hot country. Needs much water. How reach it? It has a large head, very heavy. Its tusks weigh from 150 to 300lbs. Suppose such a head on a long neck. It would require strong muscular force to lift it. Illustrate by attaching a heavy weight to the end of a long pole, and trying to raise it from the other end. Show compensation to the elephant in its trunk. It has no need to lower its head. Trunk eight feet long, prolonged snout; but hollow valves inside to prevent the water going too high. Refer to the fact that it is often away from water. It has a pouch that will hold ten gallons. Can be brought into its mouth, taken by its trunk, and discharged on flies that may be annoying it.

42.—Earthworm.

I. Introduction. Why called *earth*-worm? Compare with water-worm and sandworm.

II. Structure. 1. *Colour.* (*a*) What is its colour? How is it produced? Refer to blushing. How is it the skin is red? Compare the worm with caterpillars that change their colour with their food. The earthworm does not. Infer that it has *red* blood.

(*b*) Circulation. It is red all over; sometimes paler down one side. Compare with man. How is man's blood propelled? By means of heart and blood-vessels. Give the fact that the worm has three force-pumps and two sets of blood-vessels.

(*c*) Why has it *red* blood? Elicit that it is food for birds, that birds often fly high, that red is easily distinguished on grass or soil.

2. *Shape.* (*a*) Kind of body. Compare with a black lead pencil. Notice its pointed head. What compare it with? Other animals of similar shape.

(*b*) *Boring.* Often found coming out of the ground. Leaves a hole. This hole it has made by boring with its head. What does that show?

(*c*) *Friction.* Soil presents a rough surface. When bored through there would be great friction. What would this require? Great strength. Elicit that worms exude a slimy moisture. They do this when boring. What effect *will that have?*

3. *Skeleton.* (*a*) *Rings.* Describe them. There are 120 in a full-grown worm. They are joined by four bands. How? What is their use? Compare with the bones of a man. They preserve its shape.

(*b*) *Crawling.* Show the motion by means of a string of rings. How is it that it does not slip back? Refer to its bristles and hooks.

4. *Nerves.* Touch it. What does it do? Why is it so sensitive to touch? Refer to the fact that if you stamp on the ground worms will make their way to the surface. Refer also to moles burrowing, and show that this sensitiveness apprises them of their danger.

III. USES. 1. It makes holes in the soil; these get filled with rain, which is thus enabled soon to penetrate to the roots of the grass.

2. Elicit that leaves are often found dragged partly into the holes. Worm frightened and left its work. It takes these leaves in for food. But many of them decay, and thus become manure to the soil.

3. *Soil heaps.* Elicit that in a place where there are many worms there are numerous little mounds thrown up. How have they been? Give the fact that by this means in course of time a deep layer of soil would be laid over the land.

43.—SHEEP.

I. DESCRIPTION. An animal often seen in the fields. If you go near it runs away. Often has a black face. Sometimes two curly horns. It has four legs, a thick, woolly coat, a short, thick tail. Is the size of a big dog.

II. STRUCTURAL ADAPTATIONS. 1. *Teeth.* Where is it often seen? Why in the fields? It gets its food there. How does it get its food? How many rows of teeth? Did you ever examine a sheep's mouth? What is there at the bottom? What at the top? Bring out that it has to cut and grind. Compare with a knife and trencher.

2. *Feet.* Compare with the feet of well-known animals. A cat holds its food with its feet; so does a dog. A hen uses its feet to scratch the earth. But the sheep does not need to do these things, hence its feet only used for walking. What would it require? Point out the material—hoof. It has no feeling; hence walking, though it wears it, does

not hurt it. Point out the parts. Ask for other cloven-footed animals. In what are they alike?

3. *Wool.* Sheep live in fields. Out in all weathers. Lie on grass. Pleasant for us to do so in summer; but in winter? or on cold spring days? Wool keeps the sheep warm. We make it into flannels and clothes for the same purpose. The wool is thick, in fibres, curly, shaggy in winter.

III. HABITS. 1. How does it rise? On hind or fore feet first? What other animals do the same? Does the horse? On which side does it most frequently lie?

2. *Timid.* Easily startled. Gets up and runs away as you approach.

3. *Gregarious.* Follows the leader. Give instances in which this has led into peril. Hence called "silly sheep."

4. *Liable to stray.* Point out also with what care they have to be driven in towns, lest they take the wrong turning. How often they go astray.

44.—THE HORSE.

I. INTRODUCTION. A domestic animal. Compare domestic and wild. In form, beauty, strength, and speed it is unsurpassed. All it has is at man's disposal. It is man's servant.

II. STRUCTURAL ADAPTATIONS.

1. *Skin.* Most animals that are used for burdens have thick skins. Thin skins would be soon worn by friction.

2. *Hair.* Easily cleaned. If the hair were rough what would combing be? A painful operation. Elicit that exertion produces heat. A horse is often seen to sweat; infer that fur or wool would not be so suitable as hair.

3. *Mane.* Beautiful, adds to the horse's appearance. By reference to the fact that a slight touch on its neck acts as a stimulus educe that the neck is tender, and that the mane serves as a protection. Compare with hair on our own heads.

4. *Tail.* Long. What seen to do with it? Knock flies away from its side. Can move it in all directions.

5. *Feet.* Not cloven. What does it wear on its hoof? How are these put on? Elicit that the hoof has no nerves, *therefore* the horse has no pain from this. Point out the *weight of the* body, refer to its rapid movements,—the whole

weight of its body coming down on its legs and feet. How is the shock broken? How is it that the bones do not break? Give the beautiful contrivance by means of which it is preserved from injury.

6. *Teeth.* What does it eat? Where does it often obtain this? What sort of teeth has it?

III. HABITS AND USES.

1. *The form of its back.* How nicely adapted for riding. Give anecdotes of cases when it has seemed proud to bear its master.

2. *Notice its intelligence.* It knows its master's voice. It obeys the word of command. It even seems to understand his eye. It can be taught.

3. *Point out how careful it is.* Picks its way through a crowded street. Has been known to lift a child out of its path and put it on the footpath.

4. *How does it rise?* On its forefeet or hind feet first?

45.—THE CAMEL.

I. INTRODUCTION. Animals used as beasts of burden. Not the same everywhere. Some countries require special fitness. Give instances. Horse, ass, reindeer, elephant, camel.

II. ITS HABITATS. It is found—where? In the hot countries of the south, and of the south-east; Africa, Arabia, Syria. Describe the deserts. Want of vegetation, except at distant spots. Oases. Notice the want of water. The surface very sandy. How produced?

III. ITS JOURNEYS IN THE DESERT. It is taken long journeys. Hundreds of miles. What sort of journeys are they? Refer to the toil in walking in sand—hence these journeys very fatiguing. What else? State that the camel is capable of sustaining fatigue, hunger, and thirst. Give instances of patient endurance.

IV. STRUCTURAL ADAPTATIONS. 1. *Its hump.* This decreases in the absence of food. Infer that it becomes a source of sustenance. Compare with animals that sleep through the winter.

2. *Its stomach.* Like other ruminants. But travelling where water is scarce it has the means of preserving a supply. In its pouch there are cells in which water is kept till it is needed.

3. *Feet.* Very large, two lobes each with a hoof, but covered underneath with a strong, tough, and pliable skin, which unites the two, yet allows the foot to spread. What is the advantage of this? Suppose its foot was like that of a horse? There would be greater labour in moving over the sand.

4. *Eye.* Describe the sand storms of the desert. Fine piercing sand—very penetrating. Eye needs protection. How is this accomplished?

5. *Knee.* Kneels to receive its load. Often down a long time. Knee adapted to this. How?

46.—The Cow.

I. Introduction. Lesson to be on the cow. Where often seen? Where else? Where in winter? One of the domestic animals. How so called? Name others.

II. Description. 1. *Its head.* Sort of head? Where widest? What on its head? Not on all. Cows distinguished by the size and shape of their horns. Ears; where placed? What kind? Eyes; what sort? Heavy, dull, glazed. Thus we say of a dull lad, "*Cow-eyed.*" Refer to the gaze of a cow when you enter its pasture. How quickly it turns its head to look at you.

2. *Neck.* Long, flexible, elastic. Can reach the ground easily. Muscular exertion in lifting its head.

3. *Body.* Thick, barrel-like, compare with hog, contrast with horse. Heavy. Prized for its weight. How so?

4. *Tail.* Placed higher on some kinds of cows than on others; one of the means of telling the kind. *Long.* Used for driving away flies. Bushy towards the end, so that the hairs may spread out.

5. *Legs.* How many? What must they be? Refer to weight of the body. They have to sustain this weight. Point out the difference in shape between the fore legs and the hind ones.

6. *Feet.* Each foot has a double hoof, hence called cloven-footed. The hoof destitute of nerves, and therefore of feeling. Feet only used for walking.

III. Structure in relation to habits. 1. *Skin.* Where cow is often seen? Lying in the fields. What it needs? *A thick* skin, that it may lie with ease, and to be kept *warm. What* its skin is covered with? How this differs

from that of the horse? Rougher and thicker. Horses combed and brushed. Some farmers brush their cows, especially when they cannot be taken to the fields. What for? The friction acts instead of exercise.

2. *Teeth and food.* In the fields gathers its own food. Slowly. Goes along feeding. Avoids some kinds of plants, but will eat them in the winter along with others. How it crops its food. How many teeth? Eight in the lower jaw, when complete. How is the upper jaw formed? A calf when it is a month old has eight teeth, called milk-teeth. Gradually wear and fall out. Replaced by degrees. Changes that occur. So that the age of a cow is known by its teeth. Its age also told by its horns. How?

3. *Stomachs and chewing the cud.* Cow often seen lying, and moving its jaws. Condition placid and sleepy. Has not time to chew its food while cropping. Passes it into the *paunch*, from this it is brought back into the mouth. What for? What does that show?

47.—The Chameleon.

I. *Introduction.* Subject named. Perhaps some have read a story about it, and can tell what the dispute was about. It does not live in this country. Not warm enough for it. If brought here, where would it like to be? Tell of one that used to cling to a fender before the fire for hours together.

II. *Structural adaptations and habits.* 1. *Body.* Most lizards touch the ground with their bodies as they move along, but not so the chameleon. Point out how this is contrived. By a drawing show the convexity of its back, especially towards the head. Infer that this is due to the shape of its spine. Notice also the length of its legs.

2. *Feet and tail.* State that it lives in woods. Spends its life on trees. It can climb. It holds on to trees. How are these things brought about? (*a*) Describe its feet. It has four. On each foot five toes. Three toes point forward, two backward. These toes have joints, and where they are joined a sort of palm; hence by these feet it can clasp the branch. (*b*) But suppose it to swerve on one side. Now describe its tail. Very long, and so formed that it can twist it round the branch, and thus steady itself.

3. *Eyes.* Very large and projecting, like two globes.

Elicit that they will need protection. What might hurt them? They are covered with the same kind of skin as covers the body. What must not be covered? The pupil. State that it can, when it likes, see forward and backward at the same time. Refer to ourselves. We cannot direct one eye to an object without directing both; but the chameleon can turn one eyeball one way, and roll the other an opposite one at the same time.

4. *Tongue and food.* It lives on flies and other insects. Remarkably slow in its movements. It cannot seek them; how can it catch them? It has a long tongue, shaped like a worm, with a bulge towards the end. It can project its tongue six inches. When in its mouth it lies in a sheath. Now watch it. One of its eyes has caught sight of a fly hovering near. It immediately brings both into action. At length the fly is in the right place; the tongue darts out, and the fly is caught. It never misses its aim. What does that show? That its vision is keen. What else does it show? How was the fly caught? Then it must have stuck to it. State that the bulging part is covered with a thick sticky fluid. State that it can live for weeks without food.

5. *Breathing.* Lung very large; when filled with air, it becomes transparent; hence the ancients used to say that air was the chameleon's dish.

6. *Change of colour.* Give the facts. To what due? Refer to cause of colour in the human skin. State that in the chameleon there are two pigments, over which it has some power.

48.—The Frog.

I. *Its history.* It is first an egg, lying at the bottom of a pool of water. After some time it rises to the surface and floats. What does that show? Compare with a cork and a stone. When thus floating what surrounds the egg A jelly-like substance. After some time an eye is seen, and very soon there is a tadpole. What is it like? Where does it live? On what does it feed? Decaying vegetable matter, and differs from the frog in having soft lips, teeth, and chewing its food. How does it breathe? By gills. It changes and becomes a frog.

II. *Structure and habits.* 1. *Its abode.* Where seen? *Sometimes* on land, sometimes in water. It can live in both

air and water. Hence called amphibious. Ask for other instances. Give facts to show that it cannot do with great cold, nor with dry heat. Hence it buries itself in winter in the mud at the bottom of pools.

2. *Its motions.* Let us look at its legs. How many? Which are the longer ones? Point out that the hind ones are twice the length of the front ones. How does it move on land? It walks, or runs, or leaps. Which does it do most frequently? Point out that its hind legs being longer fits it better to jump. How? Point out also that it has strong muscles on the thighs and calf—very like those of a man. State that it can jump twenty times its own height, and over a space fifty times its own length. Infer that it has strong muscular power. Did you ever see a frog in water? What was it doing? In what way was its body? Lying flat. What does it use in swimming? What are its feet? How does it kick out? Point out that because of the position of its knee-bone its hind-feet are directed outwards. How many toes on the fore-feet? How many on the hind ones?

3. *Its food.* Lives on insects; hence carnivorous. How are they caught? Describe its tongue. Curiously placed in its mouth. Our tongues fastened at the back of the mouth, but the frog's tongue is fastened in front of its mouth, and the point is down towards its throat. How brought out of the mouth? Show that it is tnrned as on a hinge. How much of it will be out of the mouth? The whole of it. When it sees an insect near, it turns its tongue out quickly, and catches it. It never misses. What does that show? Keen sight. How caught by its tongue? Covered with a sticky fluid. Where caught on its tongue? On the upper surface. Where will this surface be in the mouth? The under one. Point out that this causes the insect to be crushed, and then it is swallowed immediately. There is no room for chewing.

4. *Its breathing.* Air is necessary to its life as it is to ours. State that it has no pharynx. That it has nostrils, which open into its mouth. That if you kept its mouth open two minutes in dry air it would die. Infer that it cannot breathe with its mouth open. How is that? Explain that the point of the tongue closes up the nostrils inside, but when the mouth is shut air enters it through the nostrils, and then is forced into the lungs, so that it is just like

swallowing. Infer that this is a troublesome process. State that it can also breathe through its skin. After giving facts, let the children infer that the skin must be moist, or it cannot take in air. How is this? State an experiment. Hold a frog in water, with its head out, for half an hour; on taking it out it weighs half as much again. What does that show? It must have absorbed water. Point out that if you surprise a frog, in its fear it will spurt out some of this water.

49.—The Rook.

I. *Its abode.* Where is it found? Builds on high trees in the neighbourhood of old mansions, or near towns. Its *nest* is built of sticks. Often contains four or five young ones. Infer that it needs to be strong to bear their weight. Forsake their nests for the woods in winter, return to them in spring. Often to be heard squabbling over their nests when building.

II. *Its Food.* Insects and grain. It prefers the insects. Likes the wire-worm and the grub of the cockchafer. Point out that the cockchafer lays its eggs in the soil, and that the grub is found there. How does the rook get them? Look at its bill. Long, thick at the base, pointed. Thrusts it into the soil and turns the soil over. Wears away the feathers at its base. It is often seen following the plough. What doing? What will the plough turn up besides soil? These grubs very destructive. Sometimes the rooks eat grain and seed. This not liked by farmers. Sometimes farmers have killed all the rooks, and next harvest had no crops. What does that show? Hence it ought not to be grudged the grain. Grain its wages for good work done. What is the food of young rooks? They eat cockchafers. They find them on trees. In what months?

III. *Its voice.* *A croak;* but it can produce other sounds. It has some power of mimicry, and has been known to "bark" like a dog, and to imitate the note of a jackdaw.

IV. *Its colour.* Usually black; but some young ones have whitish feathers. This is a sign of weakness. Old birds sometimes change to a lightish colour.

V. *Its feet.* Three toes forward and one backward; each has a hooked claw.

50.—Animals.

I. *Growth and power to obtain food..* Compare a vegetable and an animal. Both grow. The vegetable is confined to one spot. There it draws the means of support by its roots and leaves. Animals have to *seek* their food, hence they have the power of motion, and an arrangement of organs for that purpose.

II. *Difference in the clothing of animals.* Man's skin thin and soft. Compare with that of the horse. The difference is because of the difference in habits. Look at the sheep and the goat. Both require warmth, for both live *out*, and are often found on hills, yet the sheep has wool and the goat hair. Why this difference? Point out the compensation to the goat in its more active habits. Give other instances, as that of the dog and cat, duck and hen. Infer that each animal has that covering which best suits its habits.

III. *Differences in external structure.*

1. Notice differences of form in classes of animals.

2. Point out differences in the size and shape of the head. Give remarkable instances of adaptation.

3. Describe the feet of the horse, cow, dog, cat, hen, duck. Could one be interchanged with another with advantage?

4. Point out differences in the ears of common animals, such as cat, dog, sheep, hare, cow, horse. Point out special adaptations.

5. Infer that each animal has that special provision which suits its habits best.

CHAPTER VI.

LESSONS OF INFORMATION.

School life, as observed on a preceding page, may be divided into three periods, each having its special characteristics, and presenting therefore distinct objects to the teacher. In the first period the great purpose is to put the child in possession of those faculties of intelligence more immediately connected with the senses. The development and culture *of these faculties* themselves, rather than the mental

stores that may be accumulated by their means, should be the constant aim. Not that such lessons can be given without furnishing the mind, nor that such a test ought not to be applied, as, "How much has been carried away?" But as it is easier to give forms of words than to develop ideas, and as it is quite possible for even a good teacher to be deceived by the appearance of knowledge when the reality does not exist, it is highly desirable that the former should be the test of success.

Not losing sight of the preparation and discipline of the instruments by which the materials of knowledge are obtained, yet as the child advances in power another object must be pursued. There are faculties of the intellect which will require culture. But before such culture can proceed the mind must be stored with the materials on which they work. The junior period is this storing-time. The memory now is strong and tenacious. It should be filled with such facts as the child may need for its after growth. Nothing should be given into its charge but what is worth its guardianship; and care should be taken that it is so given as to prepare the way for that more active employment of the intellect which belongs to the succeeding period.

Here, then, we find our rules for the lessons of the period. Of course it is assumed that during the whole time the child is advancing in the arts of reading, writing, and arithmetic, and that it is taught to apply these so as to advance the general purpose of the period.

The period is marked by a marvellous growth of language, and the child is apt at taking words which to him have no meaning. Now this process, which it is neither possible nor desirable to prevent, will furnish a great obstacle to successful teaching. If the teacher is not careful, forms of speech will be picked up, and words, only words, lodged in the memory. But the mind must be stored with ideas, facts, and thoughts, not with verbiage. The facts and things given must be more than a form of words. They must be clear and intelligible. Often children answer questions accurately when they have no real knowledge of the things. The question awakens some verbal association and the right answer comes forth. This must be prevented.

Some things can gain an intelligent admission into the *minds of children* only through "Picturing out" or graphic *description*. Obviously, then, it becomes the duty of the

teacher to cultivate this power. It is not easily acquired by some. Evidently it cannot exist, unless the teacher has the habit of vivid conception and fancy. To this he should address himself. Aid will come from familiarity with poetry and prose, in which it is richly displayed; an intimate acquaintance with the works of such writers for children as Abbott will help to its possession; and the use of good homely Saxon will render it more effective. Facts of another class can be only intelligently presented through the medium of analogy. Illustration is thus another of the teacher's forces. The power to do so effectively depends on the variety of his own mental stores, on their freshness, and on their being at command. To have this power he must ever be adding to his mental wealth. He must also gain the habit of looking at everything he gets in the light of its power to set forth something else. And he must cultivate readiness by the practice of instantly grappling with any difficulty that presents itself. Other facts will require the aid of experiment. Here it will be the teacher's business to keep the point to be made clear before the class, and to direct their observation to that particular in the experiment that illustrates this point. The more novel the experiment, or the more exciting its character, the more likely will it be to attract interest to itself, to the exclusion of that which was to be made plain.

That the information given may be clear and intelligible, there must be good questioning. It is only by judicious use of interrogation that the desire for knowledge is stimulated, the pupil saved from vague notions, and his mind kept from that stagnant condition which attends simple receptivity. But questioning answers several distinct ends, and its form and spirit are moulded by these. In fact, that it may be effective, the precise design of the questioning must be kept in view. Thus at the beginning and continually during a lesson, there is a species of questioning the aim of which is to lay bare the pupil's mind, to disclose exactly what he knows, to make clear to himself as well as to his teacher the exact limits of his knowledge. This is necessary to prepare the way for instruction, to make the pupil feel his need of it, and to excite the desire for it. Every good lesson as it proceeds will abound with this kind of questioning. But there is another kind having an entirely different aim from this. It makes clear to children what they possess,

and it leads them along a definite track, by questions based on previous answers, to infer things that were before unknown. It is indispensable to its success that no question shall suggest any of the facts, or anticipate the conclusion to which they tend. It is to wear the aspect all through of a process of investigation, inference, and discovery by the pupil himself. There is also a third kind of questioning, the object of which is to ascertain how much of the lesson has been carried away. But in addition to these there is a further kind necessary during the course of a lesson, at the end of each of its divisions, the aim of which is to give to the pupil the thorough mastery of the subject. The process is both examinative and instructive. It makes apparent imperfect apprehension, and by the demands it makes on the intelligence it secures that each thing is understood. When skilfully used it becomes an effective teaching process. That which was seen but dimly, or not at all, stands forth in a clear light. That of which the conception was but vague or erroneous, becomes an intelligent possession. That which was verbal only becomes real and significant. For instance, if a question elicit a verbal reply, right in fact and in form, other questions would follow to disclose whether it was understood. Or if a question should fail to obtain an intelligent reply, or should make manifest an imperfect notion, or a misconception, other questions would bring out things by which these would be cleared up. And so it would go on, till under the stimulus thus applied the subject was in the pupil's grasp.

That the information given may be permanent, attention must be given to the ultimate form in which it is committed to the memory. The first step is to give clear notions and to exact these from the children in their own language. Next they must have given them the means of expressing themselves more accurately and technically. The teacher is first to save his pupils from mere forms of speech which awaken no corresponding thought, then he has to save them from loose speech, which would follow the neglect of technical terms.

Notes of Lessons :—Information.

51.—*Hills.*

I. Inequalities of Surface. Refer to some neighbour-

ing roads. Some are flat. You walk on level ground. Others are not flat. Specify some. As you walk on you begin to walk *up*. At length you get to the *top* and look *down*. The land where you now are is raised. It is much higher than the surrounding land. We call it a hill or a hillock. Then a hill is land that is higher than the flat land about it.

II. STEEPNESS. Take a hill which the children can see or have visited. Easier to go down than up. Tell of some hill where you have to *climb*. From jutting portion to jutting part, from crag to crag. Such hills may be called *steep*.

III. HEIGHT AND PROSPECT. State or elicit that as you ascend you can see over the tops of trees, over the church steeple. That as you go higher and still higher these look *little*, down far below. Tell, too, that to get to the top of some hills would take several hours of fast walking. But when there? What a wide range of view. Give some hills and their heights.

IV. PARTS OF HILLS. 1. *Base.* Suppose that you could remove a hill just like you can cut down a tree, there would be ground left where it stood. This is called the base. Show that the base is sometimes very large. Give Plinlimmon and other instances. Take some near hill; how long would it take to go round it?

2. *Foot.* In ascending the hill where do we start from? Distinguish between the *base* and *foot.*

3. *Sides.* What shall we call that part over which we walk as we ascend? It slopes or slants. In some parts it is hard to climb, it is so steep. We call it the side.

4. *Summit.* Then we get to the *top*. Sometimes flat, sometimes rounded, sometimes a ridge. Look about you. You can see trees, houses, steeples, far below you. You are very high up. What do you say of the wind? It is colder than at the foot. Suppose a fall of snow, where would it lie the longest? On the summit. How is that?

V. WHAT HILLS YIELD. 1. *Herbage and trees.* Draw attention to what is found on the slope and summit. Grass or heath, or trees; and if trees, what sort. What are feeding on them? On some sheep, on others goats.

2. *Quarries.* Refer to stone used for building, to slate for roofing, &c. Where these obtained? What call the place?

3. *Springs and streams.* Take them a little way over the

slopes. There is a nice little hollow and a tiny valley. Look! Water is bubbling up, and in flowing down has scooped for itself a bed, or channel. Here we have a spring and a stream, the beginning of a river. What do you call it?

52.—Uses of Hills and Mountains.

1. *Introduction.* Compare hills and mountains. That which is called a hill in a mountainous region would be called a mountain in another. Hills generally rounded and covered with soft soil, mountains usually peaked, ridged, rocky. Set forth the subject of the lesson. What use are hills and mountains? What would be the effect if the earth's surface were level?

2. *They give beauty to the landscape.* Draw attention to the pleasure derived from a broken surface. How the eye wearies under a monotonous outline. Contrast a flat district with one of undulating surface, and again with a hilly one. Describe some of the sublime aspects of mountainous regions. Infer that mountains add to the earth's beauty. God likes to give us pleasure, He has scattered beautiful things in profusion all around.

3. *They are often reservoirs of water.* There are lofty summits covered with snow, this in summer melts, and water flows down their sides into the valleys and plains below. But often immense hollows exist in them. The rain that falls penetrates and is collected and preserved. From these it flows out gradually, so that man's wants have been considered and provided for. Hills thus furnish fountains and springs of water.

4. *They render the earth habitable.* Because there are hills and mountains the land slopes. It is also broken up into hollow places and valleys. Hence when rain falls, that which does not penetrate through the soil does not stop on the surface, but runs down the slopes, forms for itself channels, and finds its way to the sea. Without mountains and hills the torrid zone would have been a belt of sand, the temperate zone an extensive swamp, and the frigid zone a cap of ice.

5. *They are promoters of civilization.* Give some idea of the strata of the earth. Show that building-stone and many clays, minerals, and metals would, if there had been no mountains, have been so far below the surface that they

could not have been reached by man. Hence man could not have made the advances he has. What would man be without stone for his dwelling? coal for his comfort and manufactures? metals for his tools? Mountains have placed these within his reach.

53.—Rivers: Source and Course.

1. *Introduction.* Take a neighbouring brook or rivulet. Get from the children all they might observe. Set forth clearly the meaning of the terms rise, course, winding, bed, channel, banks, and mouth. Rivers *rise*, *flow*, and *fall.*

2. *Head, source or rise.* Give instances to show that rivers have various sources. Some flow from lakes, others from glaciers, many issue from springs. By instances show the varying heights of their sources. Shannon 258 feet, Severn 1,500 feet, Rhine 7,650 feet. By a diagram give the relation of the height of the source to the mouth. By instances show that the volume of water issuing from springs varies. In some cases a considerable stream. What does that show? There must be a large internal reservoir. In other cases a bubbling rill. Show also that the flow varies. In some rivers it is continuous, in others intermittent. How account for this? The latter are surface springs, and are affected by the rainfall.

3. *Course and channel.* Distinguish between the terms. (*a*) *The course.* On what does it depend? From instances, as the Thames and its affluents, show that it is determined primarily by the general slope of the country. By other instances, as in the upper course of the Severn, show that mountain spurs change their direction, because of the obstacle they offer to the water cutting its way. (*b*) *The length.* By comparing the Severn with some of the shorter streams of Wales show that it depends on the configuration of the land and also on the area it drains. Show also that according to the character of the soil or strata in its way there would be more or fewer bendings or windings. Infer that the direct distance from the source to the mouth may be short as compared with the river's length. Instance the Rhine. (*c*) *The channel.* State that the channel of a river often varies in width at different parts of its course. Thus one place may be much narrower than another higher *up the stream.* How is this? Refer again to the character

of the strata through which it has made its way. Some have offered less resistance, others more. Here the channel narrows, there it widens.

54.—Rivers: Volume and Velocity.

1. *Magnitude.* What is meant by the term, On what does it depend? (*a*) *The supply.* First, there is the spring or source; but this offers a very small contribution in many cases. Then there are *affluents.* The river is a great trunk into which at different points veins open. With what effect? On the volume? On the channel? Then there is the area drained by the affluents. There are also, in many rivers, springs which add largely to their volume. They might be called underground affluents. How so? (*b*) *Modifications.* Rivers vary. In some there is a pretty regular flow, with but occasional disturbance. In others, the volume varies greatly with the season. The channel fills, the river overflows; then at another time there is a lowering, or a scant quantity. To what due? By appeal to what they have observed in heavy rainfalls get them to conceive the process. Again, by such facts as there being no perceptible rise in the Thames on a heavy fall of rain after prolonged dry weather, with the difference at other times, lead the children to infer that much of the strata may be porous and absorb. State also that in this way internal reservoirs may be formed, which shall be springs to rivers in other basins.

2. *Rapidity.* Some rivers slow, others rapid. Some are rapid in their upper course, but slow in their lower. To what is rapidity due? Draw attention to the influence of height. How is this modified? Show that it is very much affected by slope. Suppose a great height, long course, gradual slope—What then? Again, a great height with a short straight course. What else affects it? Suppose equal volumes of water in a wide and narrow channel, which would have the greater velocity? How so? Suppose also a straight course and a winding one, which runs the faster? What is the effect of the windings? How? Whereabouts will the stream be most rapid? What will retard it? Friction of the sides and bed.

3. *Deposits.* Notice their action on the soil. The large quantities brought from the hills in heavy rainfalls. How not deposited in the upper course? Velocity prevents.

Where deposited? What the result in the channel? Islands and bars. What in the mouth? Deltas. Notice action of the water on the sides of the channel. Scoop out and make hollow, over-hanging banks, which sometimes fall in, thus the channel is enlarged.

55.—Uses of Rivers.

I. Water is necessary to vegetable and animal life. Establish this, or rather educe it from familiar and well known instances.

1. What would be the effect if the supply was by rain only? The rain running off the surface as it fell.

2. Notice the means of collecting and storing it in natural reservoirs in hills.

3. Show how the conformation of the surface, and the character of the crust admit the formation of rivulets and rivers.

II. Advantages to organised beings.

1. *Vegetation.* (*a*) Notice advantage to the land bordering their banks. Through absorption by the soil, and to the evaporation, which moistens the atmosphere. (b) Point out how distant surfaces are benefited by drawing off surplus waters. (*c*) Show the benefit to the farmer who employs a system of irrigation. (*d*) Show the advantages of those rivers that have periodical inundations in the deposit of soil over a large area.

2. *Animal life.* (*a*) Elicit that the rivers bring water within the reach of man and other animals. (*b*) Rivers by drainage of the land make the atmosphere drier than it otherwise would be. Compare swampy districts with hilly ones. The difference in temperature in a dry as compared with a damp atmosphere. (*c*) Rivers add to the salubrity of districts by agitating and purifying the air. How?

III. Commercial advantages.

1. They furnish sites for towns. Point out important places on rivers.

2. They furnish an easy means of working machinery. Refer to corn-mills as worked by wind, steam, and by water-fall.

3. They give the means of intercommunication. Point out the *particulars* that affect the navigation of rivers.

56.—The Thames and London.

I. The River. The name. Where first given? Why? Point out Isis. Give its four affluents. Draw attention to the source of the longest, the Churn. Give its height. Ansted says about 376 feet. Compare with mouth to show the fall. How affected? By slope which is very gradual. Point out the chief tributaries. Elicit their effect. What on its width? Its volume? Its velocity? Give the width at a few points.

II. London. Give the origin of the name. Notice what would strike attention if standing on London bridge. Up and down the river. Warehouses, steamboats. Looking down the river, and proceeding down. Ships, steamboats, warehouses, docks. Give some notion of the length of London along the river banks. Notice the reaches of the river and its bendings. Give some notion of the trade of London. Its imports and exports. All parts of the world represented. Give its population. How has such a place and such a trade grown there?

III. Growth of London. 1. *Position of the Thames.* South of England and far up into its land in its broadest part. Notice its windings and their effect in retarding its rapidity. Give Hughes's calculation of its velocity at London bridge had its course been direct. Then no ship could have ascended it. Now it is navigable.

2. *Tidal.* Draw attention to the tide, and to the extent it runs up the river. Give high-water mark at London bridge. Point out estuary. Explain the term. Compare frith, loch. Point out embankments by which the channel has been narrowed. River navigable by large ships.

3. *Position of its mouth.* What is the general direction of its course? West to east. Suppose that it had been reversed, its mouth opening to the Atlantic? But it points to the Continent of Europe. Hence in a favourable position for intercourse with Holland, Belgium, and France. State that its early commerce was chiefly with these. Compare its growth with Chester, Bristol, and Liverpool.

57.—The Severn.

I. Its situation. Inspect the map for this. Point out

extent of country eastward, westward. Draw attention to the *name*. Originally *Hafren:* called by the Romans, *Sabrina*.

> "There is a gentle nymph not far from hence
> That with moist curb sways the smooth Severn stream;
> Sabrina is her name, a virgin pure."

1. *Its source.* Rises on eastern side of Plinlimmon. What is that? Issues from a small lake formed by a chalybeate spring. Explain chalybeate, and give other instances. Height of source, 1,500 feet.

2. *Its mouth.* Forms an estuary. What is that? Ask for others. Compare with frith, loch, bay. Notice how it opens, increasing in width as the lands of Wales and England recede. Points westward.

3. *Its length.* Point out that its source is near the sea. Show that the Rheidol rises very near it, and after a run of a few miles enters the sea. Give the length of the Severn. How is it that the Severn is so long?

II. ITS COURSE. By inspection of the map account for the length and direction.

1. *Upper course.* (*a*) Plinlimmon to Llanidloes twelve miles. It flows eastward. How is that? Point out that Plinlimmon is the centre of ranges of hills, the *Cerri*. Show its spurs to the west and south, and the high land of Montgomery on the north. (*b*) Llanidloes to its entrance into Shropshire, flowing by the towns of Newtown, Montgomery, and Welshpool. This north-eastward. How so? Show general directions of Welsh hills and valleys, and point out that it has been deflected from its course by high land. Length to entrance into Shropshire about fifty-one miles. (*c*) Point out Welshpool. The river now navigable by barges. Notice rapids.

2. *Middle course.* At first eastward, with a little bend to the north. Most northern point a few miles above Shrewsbury. Nearly encircles that town, and bends south-east. Point out the Wrekin, and the ridge called Wenlock Edge; the Severn flowing between them, and having its course affected by them. Its course in Shropshire nearly seventy miles. Enters Worcestershire near Bewdley. After passing Worcester, receives the Teme, by which it is considerably enlarged. Leaves Worcestershire at Tewkesbury, after a run of about thirty miles.

3. *Lower course.* The river from this point enlarged by the Avon. Tends south-west. Above Gloucester divides into two branches ; unite again below the city. At Newnham the channel widens, and the estuary begins, here varying in width, down to the Avon, from one to three miles.

III. FEATURES.

1. *Affluents.* Numerous. Some large streams. Point out a few of the more important—as the Teme, Upper and Lower Avon. Notice also the Wye.

2. *Tide.* How far it extends. The *bore*, rising nine feet, and attaining a velocity of fourteen miles an hour. Height of the tide at Chepstow in the Wye.

3. *Deposits.* "The most turbid river in Europe." Passes through long tracts of marl and sandstone.

> "Three times hath Harry Bolingbrooke made head
> Against my power; thrice from the banks of Wye
> And *sandy bottom'd Severn* have I sent him
> Bootless home."

The deposits greatest on the Welsh side. With what results? The water is shallower. The temperature is higher.

4. *Navigation.* Of great importance, but much impeded The river often subject to freshets. Give the manufactures carried on at different places—Welshpool, Coalbrookdale, Bridgnorth, Worcester, and the features of the trade of Gloucester. What things are likely to be found carried by the barges on the Severn?

58.—IRON MANUFACTURE.

I. DISTRIBUTION OF IRON. 1. Iron one of the principal sources of national wealth. Deposits very abundant, and in many places often found in the neighbourhood of coal. Importance of this. Contrast with iron found in districts without coal.

2. *Point out some of the principal districts. South Wales*—Glamorgan, Monmouth. *England*—Forest of Dean, Worcestershire, Staffordshire, Shropshire, Yorkshire, Cumberland, Northumberland. *Scotland*—East of Glasgow.

II. SMELTING. Explain the process. Describe the appearance of the districts where carried on. Associated with.

coal getting. Large heaps of iron ore and coal, all in a glow. Furnaces pouring out flames. Point out a few of the towns in each district. The squalid condition of many of them and of their suburbs. Give some notion of the extent of population.

2. *Towns.* *Glamorganshire*—Point out extent of district. Positions of Merthyr Tydvil, Neath, Swansea, Cardiff. Give facts illustrative of trade and condition. Pig and bar iron. *Monmouthshire*—Point out Abergavenny, Pontypool. Newport exports iron. *Gloucestershire*—Forest of Dean, celebrated for its ironworks from the time of the Romans. The *Black Country*—Over what area it extends. Portions of what counties embraced. Very large population. *Shropshire*—Coalbrook Dale.

III. HARDWARE. 1. To what articles the term applied. Distinguish from cutlery. The Black Country covered with towns. Very near. Many very large. All engaged in the manufacture of articles from iron.

2. *Towns.* *Warwickshire*—Birmingham, the "toy-shop of the world." *Worcestershire*—Stourbridge, Dudley, Redditch. *Staffordshire*—Wolverhampton, Walsall, Wednesbury, West Bromwich, &c. &c.

IV. STEEL. How steel differs from iron. Sheffield the capital. Its situation. Its valleys, hills, streams. Referred to by Chaucer for its cutlery. Iron brought from Sweden. To what port?

59.—SILK: ITS LOCALITIES.

I. INTRODUCTION. Show silk. Elicit what the children know. It is a textile manufacture. Material supplied by silkworm. This fed on mulberry leaves.

II. CHINA. 1. *Direction and distance.* Silk first worn in China. Have map of the world. Let the class state where England is. Point out China. Its capital, Pekin. What is the direction? What is the distance from London to Pekin? State that in a direct line it is 5,000 miles. How long would it take at twenty miles a day to go that distance? Could we walk it? How not?

2. *Population and extent of silk culture.* Silk a common article of dress. Compare with cotton in England. Silk worn in China by rich and poor, from the emperor to the peasant. How many people in China? Four hundred

millions. Easy to say, difficult to conceive. Suppose we could count them, night and day, taking no rest. At sixty a minute, how many an hour? How many in a day? How many days would it take at that rate? How many years? Yes, it would take nearly thirteen years. And all these people wear silk. Now it takes 3,000 silkworms to make 16 oz. of silk. What a number of silkworms there must be in China!

III. EUROPE. 1. *How introduced.* (*a*) State that upwards of 2,000 years ago silk brought from China was woven in the island of *Cos.* (Point out on the map.) (*b*) But we have now the silkworm. How was this brought? Point out the impossibility of bringing the caterpillar. How, then, was it managed? Give the facts. Two missionaries filled a cane with eggs and brought them to Constantinople in 522. They were sent to Cos. Why? (*c*) Italy and France. The culture spread to these countries. How so? Point out the food of the silkworm. Favourable for the growth of the mulberry tree, and the temperature adapted to the caterpillar. Now it is computed that there are fifteen million mulberry trees in France alone. Point out French towns engaged in the manufacture.

2. *Introduction to England.* Explain former practice of sumptuary laws. Refer to Mary's prohibition of silk. A fine of £10 or imprisonment if found wearing silk. Could such a law be made now? Give the fact of James I. borrowing a pair of silk stockings in which to receive the ambassadors. Refer to the revocation of the Edict of Nantes, and its effect in introducing and extending the silk manufacture in England. Point out some of the places where the manufacture is carried on. Spitalfields, Norwich, Macclesfield, Leek, Congleton, Sandbach, Coventry, Derby.

60.—EQUATOR.

I. POSITION. Place a globe before the class, or a map of the world. Show the line representing it. A real line here, an imaginary on the earth. Trace it. Elicit that it is the circumference of a circle. Where is the centre? Of what else is it the centre? Draw attention to the two equal hemispheres and to the term equator. What does the name indicate?

II. LATITUDE. How many ways can we proceed from

the equator? North and south. How many points might be started from? Innumerable, anywhere on it. When we had proceeded a little way there would be an interval. What shall we call this? Then what is latitude? Suppose that we were to describe a circle, what might we call it? Line of latitude. What are lines of latitude? What are they in all their parts in relation to the equator? What is the greatest distance we could go from the equator? What are these points called? How do we measure this distance? What is a degree? On what does the length of a degree depend?

III. DIAMETER. Give the length of the equatorial diameter and of the polar. What is the difference? What does this show of the shape of the earth? Where does it bulge out? How was this discovered? Would a pound of sugar weighed in England weigh the same at the equator? Notice the conditions to be observed. Scales and weights not to be used. Why not? But a nicely tempered spring.

IV. TROPICS. Give the apparent course of the sun as seen at the equator. Give the meridian heights of the sun at the greatest interval. Why call these the tropics? Give the time of the greatest meridian height. What is the effect then all over the world? What would be remarkable then at the equator? Test clearness of notions by asking for the direction of the shadow at different seasons. When the shadow falls southwards at the equator what season is it with us?

V. PLACES ON THE EQUATOR. Start from the meridian of Greenwich in the Gulf of Guinea, and go west. What ocean? What island does it just touch in the south? St. Thomas. What river's mouth when it strikes America? Amazon. What countries of America does it cross? What is the nearest town in Ecuador? Quito. What does it then enter? And so on.

61.—GLOVES.

I. USES. 1. *As a protection from cold.* Glove, a covering for the hand, compare with cap. For what purpose used? When first used? Compare with clothes. Clothes protect from cold. In cold weather something needed for the hands. Formerly might wrap them in the long, loose garments then worn. Gloves first used in winter. Introduced

it to England about the time of Egbert. At first a close-fitting bag, like a stocking; then a place for the thumb, like those for babies now; then places for the fingers. This is the way improvements come—by degrees.

2. *Protection from dirt, &c.* Notice the difference between the atmosphere of towns and of country places. Point out the effect on white things, such as collars. How much sooner soiled in towns. Notice also the action of the sun's rays. Hence gloves worn to preserve the hands clean and of a good colour.

II. CUSTOMS. 1. *Social.* Point out that some people think it a disgrace to go through the streets without gloves. Notice also presents of gloves. (*a*) At weddings. (*b*) At funerals. (*c*) At a maiden assize, of the sheriff to the judge, and of glove-money to the judges' officers.

2. *Historical.* (*a*) Refer to champion of England at a coronation. To wagers of battle, instead of suits at law. Give scene from Shakspere. (*b*) *Pledges.* Gloves given and taken as pledges of tenure. (*c*) Kings and nobles buried in gloves.

III. MANUFACTURE. 1. *Kinds.* Which is the best? Ask for the materials of which gloves are made. Which of these the best for winter? Which are the most lasting? Which are the cheapest? How so? State that most of the "kid" gloves so called are made from lambs' skins. All the kids in the world would not furnish leather enough for the number made. The best "kids" only are real. Inference, call things by their right names.

2. *Places where made.* Not grouped, like the cotton manufacture, but scattered like straw-plait. Can be made in houses. Point out on the map, Worcester, London, Woodstock, Hexham, Hereford, Ludlow, Leominster, Glastonbury, Wells, Shepton Mallet, Limerick. Places in France. Naples.

62.—WORCESTERSHIRE.

I. POSITION. One of the inland counties. Draw a line from west to east through its county town, starting from Cardigan Bay, and ending at the German Ocean, about one-third of this line from Cardigan Bay. Give its boundaries. Its length from north-east to south-west, about 29 miles. Its greatest breadth about 22 miles.

II. SURFACE. 1. *Plain.* The county is generally flat

and very fertile. Parts of the county, especially the vales of the Severn and Avon, are very little above the level of the sea.

2. *Hills.* Form the boundary of the plain, Malvern on the west. Give the height of the Worcestershire Beacon. Abberley hills on the north-west. Clent on north-east. Broadway hills south-east, and Bredon on the south.

3. *Rivers.* Severn bisects the county, enters it on the north-west near Bewdley, leaves it in the neighbourhood of Tewkesbury. *Stour* is a tributary of the Severn in the north of the county. It passes Stourbridge, Kidderminster, and enters the Severn at Stourport. *Teme* rises near Newtown, Montgomery; enters the county in the extreme west, passes Tenbury, and after a very winding course of nearly thirty miles joins the Severn below Worcester. Along its banks are hop-gardens and orchards. *Avon* enters on the south-east: it has a sluggish, winding course; passes Evesham and Pershore, and joins the Severn below Tewkesbury. Navigable by barges to Stratford on-Avon.

4. *Minerals.* New red sandstone, lias, and oolite in great part of the county. Coal-beds in the north. Salt at Droitwich.

III. *Towns.* 1. *On the Severn.* *Bewdley* (Beaulieu). Name describes the pleasantness of its situation. It has a carrying trade, chiefly in salt, leather, and malt. *Worcester.* Its name. County town. Also a city. Has manufactures of porcelain and gloves. Scene of final battle of civil war 1651. *Upton* has a large trade in cider.

2. *On the Stour.* *Shipston-on-Stour*, in an outlying part of the county. Formerly a large sheep market, hence its name. *Stourbridge*—built on a declivity. Has manufactures of iron, glass, and fire-bricks. Large beds of sand 150 feet below the surface, used in making glass. *Kidderminster* possesses a fine church. The town once the property of Waller the poet, who had to sell it to pay a fine imposed by Parliament. Now manufactures carpets.

3. *Other towns.* *Dudley*, in an outlying part of the county. Its name attributed to Dodo, a Saxon prince, who built a castle here. There are extensive quarries of limestone in the neighbourhood, also coal-beds. It is engaged in the iron manufacture. It has chalybeate springs, and water famous for the cure of skin diseases. *Redditch* on the east. Famous for needles, 70,000,000 made weekly.

Droitwich, Stoke, and Bromsgrove. - Neighbouring towns, engaged in the salt trade. *Evesham*, on the Avon. Battle in 1265. Formerly its corporation had the power of trying and executing for all capital offences. A woman was burnt to death so late as 1740.

63.—Matter and its Forms.

I. Matter is that which has bulk or volume and occupies space. Begin by stating that the lesson is to be on Matter. What is it? Our sight tells us of the presence of many things around us. On waving the hand we are conscious of resistance. Hence, there are objects that can be *seen*, and other substances that can be *felt*. The presence of others is made manifest by their *scent*. All such objects occupy space, and therefore have volume. To these things we apply the term matter. What do we perceive in such things? Show by experiment and illustration that properties or qualities only are the objects of perception or knowledge.

II. Matter exists in different forms. 1. *Visible* or *invisible*. This to be brought out by reference to last division. Things that may be seen are—*visible*; those that cannot—*invisible*.

2. *Cohesion*. (*a*) Have a piece of wood and a dish of water. Apply force to a point of the wood, the whole piece moves. Strike the water, there is a splash. What is that? A portion of the water separated from the rest, so that if force is applied to a point in the water a part is moved, but not the whole. (*b*) Change the position of the wood, it keeps its shape. Pour water into a vessel, what happens? It takes the shape of the vessel. Such things as wood we call *solid*, such things as water we call *liquid*. Train out that these differences are owing to the differences in the force of cohesion. Cohesion is stronger in solids than in liquids.

3. *Repulsion*. Compare coal-gas and water. Turn the tap connected with a gas-burner, gas escapes. Before this it was confined. It has diffused itself. Hence its particles are farther apart than they were. Here is not cohesion, but repulsion. Such bodies are termed aeroids. Aeroids spread in all directions.

64.—Atoms.

1. Take up any object. It can be seen and felt. Other things we can taste. Some we can smell. What are all such things termed? Stone, iron, gold, are solids. Water, milk, oil, are fluids. Coal-gas and air are aeroids.

2. Matter is divisible. How? In various ways. We may burn wood. What is the smoke? What the flame? What the grey ash? They were all parts of the wood. So we may separate other things into parts.

3. Matter is made up of very small parts. Gold leaf may be beaten so thin that 300,000 leaves laid one upon another make not more than an inch. The red cells in the blood are so small that a pile of 12,000 would only make an inch in height. Platinum and silver can be drawn into wire as fine as human hair. Look at the skin. From it is proceeding perspiration continually. Yet it cannot be seen. How small the pores or sweat tubes. There are between two and three millions in the skin. Take a grain of blue vitriol, put it into a gallon of water. What has it done to the water? What does that show? That the vitriol has been dissolved and diffused. How small each part must be. Refer to a carrion crow. It finds its way to putrid food miles away. How did it know? *You* may smell a flower, can you see its perfume?

4. From such facts as these we learn how divisible is matter, and how very minute its smallest parts must be. Such parts are often termed *atoms*.

65.—Water.

I. Forms. Elicit the states in which it has been observed. Water, ice, steam. The forms are liquid, solid, aeroid. On what does the form depend? In what state of weather does water become ice? When does water become steam? Then on what does the form depend? What does water part with on becoming ice? What does it receive to convert it into steam?

II. Volumes. 1. Suppose we had a pint of water, and that it were to freeze. What would it lose? What would you expect it to become? How so? Other things contract as they part with heat. Does ice? Where do you find ice in a *pond*? What does its floating show? What would

result if ice contracted as it froze? 2. Now put this pint of water in a vessel and convert it into steam. What do you say? The vessel must be very large or it would burst it? The pint of water becomes an immense volume.

III. PRESSURE. We have here a basin of water, and I take a cupful away. What takes place? The void is immediately filled up. Compare with cutting a solid. The parts remain rigid. But in water there is a rush to fill the vacancy. Hence the surface of water is level.

66.—ALFRED THE GREAT: EARLY LIFE.

I. HIS TIMES. Give the date of his birth, 849. How long since then? Point out the place where he was born. Describe the England of that period. Its population, their dwellings, food, and clothing; their roads, means of transit, and trade; their education and religion.

II. EARLY LIFE. 1. *Childhood.* When was he born? Where? Who was his father? State that he was taken to Rome at the age of five and again at the age of eight. State what took place there? What does that illustrate? Mention his fondness for Saxon poems, and the story of his winning the prize offered by his stepmother. Point out that ability to read was a rare accomplishment in those days, even of princes. What books had they? Only manuscript, hence books could not be multiplied fast, and could belong only to the wealthy. State that in later life Alfred composed books and translated several from the Latin, some very difficult. Infer that he employed his time well when young. That he made the most of his opportunities. Was he as well circumstanced as you are?

2. *Youth.* State that he became expert in hunting and shooting, and was early accustomed, as the fashion was, to fatigue and abstinence from food. He became also skilful in mechanical arts. His health was not good. He suffered excruciating pain; but he did not succumb to it. All through his life he was afflicted. In 866—How old was he then? In 866 his brother made him his chief minister, and employed him as general to repel the invaders who made descents on the country. What does that show of him? That he was held in esteem for his bravery and ability. State that he was married in his twentieth year.

67.—Alfred the Great: Contests with Danes.

I. Accession. He succeeded his brother in 871. How old was he then? State that he was king of the West Saxons. That he was during his life able to consolidate all the states. He cared not to assume the title king of England, though he may be said to be the first. What does that show of him?

II. Contests with the Northmen. 1. *Who were they?* They were called Danes, but they were most likely Norwegians, the Danes proper belonging to a later period. Give facts to show that they cultivated military science, and were esteemed as brave and skilful warriors. Infer that they were not mere hordes of undisciplined marauders, but a host that required courage to meet and skill to fight.

2. *Battle of Wilton.* State that during 871, previous to his accession, Alfred fought eight great battles. Within a month after he became king the battle of Wilton was fought. The result was a truce, and the West Saxons were unmolested for three years. During these years Mercia and Northumbria were overrun and possessed by the Danes.

3. *Naval engagements.* What were the results of these incessant conflicts? The army of Alfred was so reduced that he could no longer take the field. What must he do? He could not bring an army to meet them. Could he not intercept their supplies? He would try. What would he need? But the Saxons were not now a seafaring people. Well, Alfred formed a small fleet. How would he get it manned? Give the facts. State that in 876 two engagements took place. In the first, Alfred's small fleet attacked seven Danish ships, took one, and put the rest to flight. Later in the year, another engagement took place off the mouth of the Exe, in which the Danish fleet was completely destroyed.

4. *Guthrun.* His retreat from Exeter after the destruction of his fleet. Head-quarters established at Gloucester. Attack on Alfred at Chippenham. Desperate fighting and successive defeats of Alfred. Retires to Athelney. Relate the story of the burnt cakes, and of Alfred's going to the Danish camp in the disguise of a harper. Are these tales true? Some deny them. In history we want facts, not fables. The victory at Ethandune, five miles from Chippenham. Treaty with Guthrun. Danelagh.

5. *Hastings.* Briefly relate the facts of continued Danish incursions in the first years after the treaty with Guthrun. Alfred meanwhile strengthening his navy and increasing his army. Then the seven years of quiet, followed by the most formidable invasion that he had yet encountered. Point out on the map a few of the more important engagements of these years, on land and sea, 893—7.

68.—Alfred the Great: His Government.

I. Political. 1. *Union of the states into one kingdom.* What had been the condition? What changes had already taken place in this direction? What influence had the Northmen in bringing about this change? Point out that Alfred's measures tended to infuse a national spirit.

2. *The creation of a navy.* Ask for the circumstances that led to it. Point out that its success in its engagements would be an encouragement both to king and people. State that Alfred improved the character of the ships, so that his were superior to those of the Danes. By the end of his reign there were upwards of 100 ships. These were in squadrons stationed at different ports. What advantage in that? By reference to some of the facts lead the children to infer that some of the rivers were deeper then than they are now. How account for this?

3. *Fortifications.* Many towns destroyed by the Danes. Rebuilt by Alfred and fortified. Castles and strongholds built in various parts. What positions would be selected?

II. Improvement of the people. 1. *Dwellings.* Before his time the best houses were of wood, inferior ones of mud. On his second visit to Rome at the age of eight he would be old enough to take notice of its buildings. When London had to be rebuilt he remembered what he had seen, and he introduced stone and brick. What does that show?

2. *Education.* Give his pathetic lament. What did he do to remedy it? Tell of the learned men that he invited. Of his establishment of schools, also of a college at Oxford. State that he gathered information from any that could supply it, and wrote it, so that his people might read it in their own tongue Give an account of his translations from Latin into Saxon for the same purpose. Point out how he economized his time that he might thus benefit his people. Relate his contrivance for marking the hours. Of what was he

the inventor? What does this show? That nothing was too trivial if benefit might accrue.

III. Administration of justice. 1. *Code of laws*, Gathered from the past, revised by the aid of his council, and sanctioned by it.

2. *Divisions for the administration of justice*. Counties, hundreds, and tythings, said to have been formed by him. But they had existed before, and in other countries. Perhaps he defined their boundaries. To attribute such things to him shows his memory was esteemed.

3. *Safety of property*. Give the saying. To what due? Excellent system of police, admirable administration of the law.

4. *Treatment of pirates*. Give the facts. Why should he treat these differently than he had the Northmen? Those he looked on as warriors, fought them, made treaties with them, kept terms with them; but with the others, when he had taken their ships, he hung the men. Why this difference? Point out that the former came from abroad, but that these belonged to the Danelagh. What then? They had sworn allegiance to him.

CHAPTER VII.

Physical Laws and Technical Instruction.

The senior period is one that has special claims on the teacher. A discipline, for which all that has preceded it is but a preparation, is demanded from him. The children's progress in reading, writing, and arithmetic should be such as to leave them leisure for other things. These mechanical powers must be so utilised that they shall by their means enrich their minds, and by the teacher's aid learn how to use them for that purpose. But in addition to storing the mind, the teacher has to secure for it the highest discipline of which it is at present capable. Books are indispensable agents in this work. But there are things which books cannot do. They do not give processes. They exhibit the results of much mental work or thought, but they do not give the process of thought or work. This the teacher must supply. His pupils must be taken through such processes of investigation and thought as will at once discipline and

invigorate them, and which, as well, will put them in possession of *method*, or the ways of intellectual work.

Unfortunately, the number of children in school at this age is so small, their attendance so irregular, and their stay so uncertain, that it becomes very difficult to carry out any systematic plan of intellectual culture. What then ought to be attempted? What would be a reasonable result? Not much can be done in storing the mind, but at least the attempt might be made to give the knowledge of one subject by means of a book. But what of intellectual discipline? It has been said by a distinguished and very successful educator,—"That it matters little, in what subjects or by what methods the wealthy may be instructed, as the length of the discipline may compensate for the quality of it; but that the children of the poor and of the artisan must be instructed in such wise as will prepare them for their immediate wants, the employment to which they must shortly go." Now, whatever may be thought of the former portion of this *dictum*, the latter part, rightly interpreted, expresses the true aim of our present work. Such children should gain some acquaintance with physical laws, and should learn their application, or their working in connection with common things; so that they may get into the habit of looking for such principles, and become accustomed to the study of modes of applying them. In addition, the lessons by which such principles are given, by which the "science of common things" is laid open, should put them in possession of the method by which such principles and laws have been discovered. Not that this should be attempted by formal statement. This would be absurd. But it should be to them a practical result from the mode in which they themselves are led to discover these principles in common things.

When it is considered that the ordinary employment of many persons consists chiefly in skilful arrangements for natural forces to work for human benefit—that man does not create force, but only avails himself of existing forces—the importance of such teaching will be at once admitted. Take a common instance. A man who plans a garden and brings beauty where it did not exist, has simply availed himself of forces at hand,—forces which only wanted the conditions that they might accomplish his will. Take another case. When man constructs a reservoir in an elevated situation,

so placed as to receive the waters of neighbouring springs, and when from it he carries pipes down hill and over dale so as to bring water into human habitations, he has but made arrangements for natural forces to work for his benefit. Hence, in the light of such science, it may be safely asserted that the best preparation the future artisan could receive would be to give him the knowledge of such natural forces, with their principles and laws, and especially to give him the methods by which they have been discovered or applied.

In conducting lessons with such an object the principle or law must not be set forth as a proposition, its meaning made clear and illustrated and its proof given; that would be exposition, not induction. The teacher must set it forth as a problem to be worked out. His skill and his difficulty will be in so setting it forth as to give a tangible point for the mind to settle on, without in any way suggesting the result. In order to this setting forth of the question as a problem, all the facts involved should be elicited or stated, all the conditions clearly set forth, and the whole of them firmly held in view of the class. Then comes the question. How can we account for these facts? What is their cause? How have they been brought about? Then one will suggest, it may be, a probable cause. How shall we test it? How can we decide? Does it account for the facts? Does it agree with all the facts? Does it leave anything unexplained? Has every condition been recognised? Thus each fact must be examined in the light of the suggested hypothesis. So deal with every suggestion. As the teacher of course knows what is wanted, he will be able at once to put aside that which is irrelevant, or to point out something which will extinguish the false.

With children whose stay in school warrants it, besides the lessons on the inductive method, there should be systematic instruction in one or more subjects. In this case the ground to be passed over will not admit of this method being applied at every step. Time would fail. Nor is it essential, if a sufficient number of lessons be given on the inductive method. The value of systematic instruction as an intellectual discipline will depend on its being clear and exact, and especially on the pupil keeping before him all that he receives, so that he may grasp the relations of all the parts to the one subject that he is acquiring.

NOTES OF LESSONS ON THE SCIENCE OF COMMON THINGS.

69.—Flame of a Candle.

I. We are going to have a lesson on the *burning of a candle.*

1. I dare say you could all tell me how a candle is made, but I wonder how many can tell me how it burns?

Hands out, those who think they know! Well, *you* think it is because the tallow melts; we shall *see.*

A candle is used to give light, and that part of the candle which gives light is called *the flame.* Now if you blow the flame out, although the snuff is red-hot, the candle does not burn away; then you would say that, for the candle to burn, there must be *flame.* Well, I want to know how this flame is *produced.*

Suppose that we had a wick without any tallow round it, and were to light it at one end, it would *soon burn away.* Yes, the wick *easily burns.*

Now suppose that we were to take a flame and hold it to the tallow, it would *melt* and *not burn;* if you held the flame to the wick, it would burn, but if you held it to the tallow, that would melt; then you would say that the wick burns more easily than the tallow, or that the tallow——? What made the wick burn? *Flame.* Well, what is there in the flame? *Heat.* Yes, heat in the one case burns the wick, but only melts the tallow. Does the tallow ever burn? If we light a candle now, and leave it for an hour or two, we shall find that not only the wick, but also the tallow has been burnt. But that heat which burns the wick will only melt the tallow; then you would say, as the tallow has burnt, it must *have had more heat.* Yes, tallow requires more heat to burn it than the wick.

2. We might now inquire how it is, as the wick is so easily burnt, and the tallow so easily melted, that when a candle is lighted all the tallow does not melt easily, and how it is that the wick does not burn so quickly. Well, we cannot stop to inquire about that just now, but we see that the tallow keeps the *wick from burning.*

3. I dare say you have often taken notice of a candle *that is lighted* for the first time; your mother goes and cuts

one, lights it, and after burning a little it *goes out;* or you have taken notice that when a candle has been snuffed very close, and you try to light it, it does not *light at once.* Now what is the reason of this? You told me that the wick does not require so much heat as the tallow, hence the candle goes out because there is not *sufficient heat to burn the tallow.*

4. A little boy told me just now that the flame was made by the melted tallow. Now we shall soon see whether he was *right.* I dare say you have all taken notice that when a candle has been snuffed too close, a great deal of the tallow has melted; now if melted tallow made the flame, you would expect this to *become flame*, but instead of that it makes a gutter on one side, and runs down the candle.

Now if you were to put some tallow in a spoon, and hold it over the fire, it *would soon melt;* now touch it *with a light*, it will not—burn. Why? *Because there is not heat enough.*

But still keep it over the fire till the spoon begins to get red-hot, and the tallow begins to go off in vapour; now take your light, touch the vapour, and it takes fire.

I dare say you have often blown a candle out, and seen a light smoke come from it; now put the candle towards the light of another, and this light smoke takes flame; hence, before you can have a flame, the tallow must not only be melted, but must be turned into vapour by heat.

II. Sometimes when you light a candle, it burns down to the tallow and then goes out. How is this? There is not sufficient heat to convert the tallow into vapour.

Light a candle; that part which was lighted first will be the hottest, in the hottest part the tallow will be first converted into vapour, then before it can be turned into vapour it must ascend.

Now describe a fine tube placed in any fluid; the fluid ascends by what is called capillary attraction.

What forms the wick of the candle? Cotton threads. These are so placed as to leave spaces between, forming fine tubes; hence the melted tallow ascends by capillary attraction.

III. *The shape.* When bodies are heated, they expand and occupy more space; hence the air round the flame of the candle will be heated and expanded.

But when air is heated and expands, the denser air rushes

in; the denser air is below the candle, and as air presses in all directions, when the air round the candle is rarefied the dense air will press upwards; hence the conical shape of the flame.

IV. *The dark cone.* If a fire is going out, you put the poker into it, and raise it, and rake out the ashes, or you take the bellows and blow it; or if a candle is blown out, you blow on it, and it again lights; now, as you send air when you thus blow, there must be something in the air that *helps* the fire.

Put a candle under a shade, and in a little while it goes out, because it has no air; then there is something in the air that is *necessary* to combustion. This is oxygen; it helps or supports combustion: if one person helps or supports another, he is called a supporter; and oxygen, because it helps or supports combustion, is called a supporter of combustion. Now when a candle is lighted, there will be required the tallow, to be turned into gas, and the air, or there will be no combustion.

The gas will ascend from all parts of the red-hot wick, but the air can only get outside the wick; then there must be some gas which the air does not mix with, and if the air does not mix with it, it will not burn.

Now look in the flame of a candle. What do you observe? The outside is very bright, and the inside dull. Now if you put a pipe into that dull part, and light it at the other end, it will light like a candle; then that dark part must be made of unconsumed vapour.

70.—Lime and its Uses.

I. Production of Quicklime. 1. *Limestone.* Exhibit a piece. Elicit it is a mineral. Compare with ironstone. It is not lime, but contains lime. Hence not a simple substance, but a compound.

2. *Quicklime.* Show some. How it differs from limestone? In colour and hardness. Elicit that a change has been effected. How? Refer to kiln. Its use. Elicit what they have seen. Infer that the change was produced in the kiln. What by? It must have been by heat.

3. *Change.* What change has taken place? What is a change? Either an alteration in *form* or in *substance.* *If the change is one of substance then something must have*

been added or taken away. Give instances of the action of heat. Suppose it applied to a mixture of salt and water. What would take place? The water would be driven off, and the salt remain. Give other instances of its action. So it does here. It drives off a gas. This gas cannot be seen, but its presence may be made manifest. How? Tell that the gas thus given off, and gas given off in breathing, are the same. Give its name, carbonic acid.

4. *Carbonic acid.* Give instances of its effects, so as to make clear the sort of gas it is.

5. *Lime converted into limestone.* Examine on facts already given, so as to bring out the essential distinction between lime and limestone. Infer that if lime could be made to absorb carbonic acid it would again become limestone. Give facts which will lead to the conclusion that lime rapidly absorbs carbonic acid from the atmosphere.

II. USES. 1. *Mortar* (*a*) What is it? Obtain from the class its ingredients. How can we mix lime and sand? The lime must be in powder. How is this done? The class will tell that water is poured on quicklime, heat is given off, steam produced, the lime cracks and becomes reduced to a fine powder. What is this called? (Perform the experiment). (*b*) *Mortar is adhesive.* What is mortar used for? It is placed between bricks to fasten them together. What then must it be? To which of the ingredients does it owe this property? Show by the soiling of the fingers that this property is due to the lime. (*c*) *Mortar becomes hard.* Elicit this fact. If it is good mortar, that is, has plenty of lime in it, it becomes very hard. How is this? Deal with the answers so as to show that it is not because it has dried. Refer to what has been said of lime becoming limestone. Recall that we breathe out carbonic acid. Show that many other things give it off: then it exists in the atmosphere. Infer that mortar becomes hard through the lime taking up carbonic acid. (*d*) *When ought mortar to be made?* From the facts already given, infer as soon as possible after the lime is reduced to powder. In which state, as a mass or powder, will it be most easily converted into limestone?

2. *Lime-wash.* The children should now be able to infer that lime-wash is useful for ceilings and other parts of houses. Carbonic acid is breathed out, and the air becomes

unfit for its purpose. Lime absorbs and purifies the air. Infer that lime-washings should be frequent.

3. *Lime on land.* The fact will have been noticed. The children should be able to state what is going on in the places where the lime is scattered.

71.—Flannel.

1. Exhibit a piece of flannel, and elicit a few of its most obvious qualities.

2. What is the chief use of flannel? To wear as clothing. Yes, it is worn very frequently next to the skin. Why is flannel so used? Bring out, by comparing different substances, that some things permit, and others prevent, the escape of heat. That those substances which transmit heat easily are good conductors.

Now, by comparing the sensations produced by the touch of linen and flannel, draw out that flannel is a bad conductor. Then what sort of clothing? *Good*, because it prevents the escape of heat. Now refer to summer—ought it to be worn then? Train out the cause of heat in summer—then flannel will prevent its admission. It is, therefore, a good article of clothing, both in summer and winter.

3. Direct attention to perspiration. Notice the feeling and danger arising from damp linen. By familiar instances draw out that flannel absorbs. Now infer that flannel promotes the comfort and health of the wearer.

4. How does perspiration escape from the body? Train out the existence of pores. Show that the action of the skin and of the lungs have the same object. By reference to a "common cold," explain that when the pores are stopped, the lungs have additional work; that, in fact, a common cold consists in the lungs doing their own work and that of the skin. What then? The pores must be kept open. Refer to the surface of flannel. What will be its action on the skin? There will be much friction, and this friction will keep open the pores of the skin. Then flannel next the skin is very *beneficial to health.*

72.—Leaves of Plants.

I. Plants feed through their leaves.

1. *Plants are found both in air and water.* Elicit this fact from the children. Those in water are termed aquatic.

Some kinds can live in both. Point out the remarkable change in the leaves of a plant when it grows in water. Our lesson, to find out the reason for this change.

2. *Without air plants droop and die.* Educe that there must be something in air and in water necessary to their life. How find this out? Show its truth in respect of air by referring to a plant placed under the receiver of an air-pump, and the air pumped out. It loses its colour, sickens, droops, and dies. Infer that the same would take place if the experiment were made with water.

3. *Without leaves plants sicken.* By reference to some plants that have been stripped of their leaves, show that it is through their leaves that they feed on that which is in the air and water.

II. Plants feed on carbonic acid.

1. *Carbonic acid gas is found in air.* Elicit that air contains carbonic acid gas. Refer to breath. It differs from air. Air enters the lungs, leaves oxygen behind. That which comes out not pure air. Show by experiment. Refer also to a room containing many people. Before they entered a lighted candle would burn in any part; but when they have been there a long time, if the candle is placed near the ceiling it will scarcely burn at all. Perhaps it goes out. Elicit also that people that have slept in beds with curtains drawn round them have been found suffocated. Breath is poisonous. That which makes it so is carbonic acid gas, which it brings from the blood in the lungs. Now consider. Hundreds of millions of men, women, and children, besides innumerable other animals, are giving out this gas every moment. That this has been going on for thousands of years. That many other things produce the same gas. What then? You might think that the air by this time would be unfit to live in.

2. *Water contains carbonic acid.* Take water, drink it; boil it and drink it. What difference? It has not the same taste. Something must have been expelled from it. Give other facts—as those connected with experiments on water under the receiver of an air-pump. These facts show the presence of carbonic acid gas in water.

3. *Plants give out oxygen and feed on carbon.* As both air and water contain carbonic acid, and plants feed on something in air and water, what might we infer? Give an account of the experiments by which this has been

shown to be fact. Plants take in the carbon and give out oxygen.

4. Infer that leaves help to keep the air fresh.

5. Why is there a change in the shape and number of leaves of a plant when it lives in water?

73.—Sound.

I. Sound is a result. Give the notion of vibration. Produce a sound by a bell or a string. Show that the sonorous body is in a state of vibration. From experiment with air-pump, lead the class to infer that the vibration is communicated to the air, as, if the air is exhausted from the receiver and a bell rung, no sound is heard. No air, no sound. Referring to the ear, how make manifest that the tube is not open right into the head? Covered by a very delicate membrane, the drum. If the vibrations reach this, it is made to vibrate too. Here, then, we have a series of vibrations, and the result a sound. Hence we infer,—

1. That there must be a sonorous body.
2. That there must be a vibrating medium.
3. That there must be a receiving instrument.
4. That if there were no ears there would be no sound.

There would be vibration, but not sound. Infer also that in many parts there may be vibrations such as the "crash of echoing thunder," and yet *no* sound, because there is no ear to receive the vibration.

II. Sound is conveyed through various mediums. Give facts of persons hearing under water—of people placing their ear to the earth. Get a lad to place his ear at one end of a desk while you gently scratch the other. In this way bring out that sound may be conveyed by various substances.

III. Distinctness and loudness. Compare sounds at night with those heard in the day.

They are more distinct. How is this? Show that the air at night contains more carbonic acid, and that it is colder, hence it is denser. Point out also that sounds under water are louder and more distinct than in air. From such facts elicit that the denser the medium, the louder and more distinct the sound.

IV. Uniform density. By appropriate facts lead to the *inference* that sound is best conveyed through a medium of *uniform density*.

74.—PERSPIRATION.

I. NATURE. 1. *Sweat and perspiration.* Name the subject of the lesson. When it is seen what is it called? By experiment with glass show that it is going on when not seen. Hence there are two forms, visible and invisible, but termed sensible and insensible. The former is called *sweat.*

2. *Perspiration gives the same elements as respiration.* Compare the two terms perspiration, respiration. Give their meanings. One means breathing through; the other, breathing back. By reference to experiments show that breath is composed of vapour and carbonic acid. Infer that sweat has the same elements. How prove it? State that it has been proved.

II. SOURCE. 1. *Separated from the blood.* Show that in respiration vapour and carbonic acid are separated from the blood in the lungs.

2. *Blood brought to the surface.* Infer that sweat is separated from the blood. Refer to the bloodvessels and capillaries. From blushing, slight cuts, and other illustrations, infer that blood is brought by these tubes to the surface of the body.

3. *Secreting and transmitting apparatus.* Infer the existence of an apparatus for separating sweat from the blood. Describe the secreting glands and the spiral tubes of the dermis. The number of these varies in different parts. But there are upwards of two millions in the whole.

III. AMOUNT. 1. *Extent of skin.* Let the children tell that the whole surface perspires; but from the fact just given unequally in different parts. Suppose the skin to be stripped off, and pieced so as to form a rectangular figure; that of a middle-sized man would make one five feet by three. How many square feet? How many glands and tubes in that space? Then as each acts constantly, the amount will be considerable.

2. *Modifications.* Refer to the influence of *temperature.* To the difference between a warm dry atmosphere and a damp cold one. What is the influence likely to be in each case? Refer to the loss by violent exertion—sometimes upwards *of 1 lb. in* an hour. Refer also to the effect of

emotions—some check it, some increase it. Show also that it is affected by the health, and by the character of the food. Give the average—varying with the size of the man—about 20 ounces in 24 hours.

IV. CHECKS. 1. *Cold contracts the vessels.* Ask the class for the effects of heat and cold. A high temperature expands, a low one contracts bodies. Infer that under the influence of cold, the bloodvessels of the surface will be contracted, and will not hold so much blood. Also that the spirals and other tubes will be contracted, and the quantity flowing through diminished. Hence, under the action of heat, there will be more blood at the surface and a greater flow through the pores.

2. *Tubes easily stopped.* Refer to the fineness of the pores. Number varies in different parts, but average upwards of 2,000 to the square inch. Infer that they may be easily stopped. How? By dirt, of course. Show also that the perspiration may congeal under cold or wet, and so stop them. Hence the danger of draughts, and of wet clothes. Show also that one in a sweat going to a fire may have the moisture dried up too quickly, and that which is left may stop up the pores.

V. INFERENCES. 1. That when the pores are stopped either poisonous matter must remain in the system, or other organs, as the lungs and kidneys, must have additional work.

2. Infer also that colds, coughs, and various diseases have their origin in the stoppage of the pores.

3. Infer the importance of cleanliness, friction, exercise, and proper clothing.

75.—PENDULUM OF A CLOCK.

I. WHAT A PENDULUM IS. 1. Let the class describe any they have seen. Of what made? What are its parts? Correct, if necessary, their conception of it. Bring out that a weight attached to the end of a thread of inappreciable weight, and so suspended as to admit of swinging to and fro, would be a pendulum.

2. Educe that the weight, being in its movements always *at an equal* distance from the point of suspension, must *describe* an arc.

3. Revise so as to show that a pendulum has a point of suspension, that it has a weight at the end of a thread, and that in its movements it describes an arc.

II. EQUILIBRIUM. 1. Take a rod, a penholder, or a black-lead pencil; hold it in a horizontal position, slip on it a thread with a small weight attached. Let it be placed where the weight may be at rest. Let the class state that the weight is exactly under the point of suspension. How is that accounted for?

2. If the thread were severed, what then? How so? Where would it strike the ground? Then what is the direction of its fall? That of the string from the point of suspension. Tell me what holds the weight at rest? The class ought to see that there are two forces acting in opposite directions,—the string attaching it to the point of suspension, and gravity.

III. OSCILLATION. 1. Recall that the pendulum in motion swings to and fro; this called oscillation. How is it produced? Suppose the weight was drawn on one side and then severed, what would happen? It would fall in a direct line to the ground. Well, suppose it not to be severed, but the hand to release it, what then? Educe that in virtue of the two forces acting upon it, it must move between them, and describe an arc until it comes under the point of suspension. Does it stop there? How do you account for that? Elicit that the force of gravity is acting upon it without intermission; give other examples, as of a ball falling from a height, or rolling down a hill; infer that this is the cause of its increased velocity. Thus moving with greater velocity the force of gravity is overcome, and the weight ascends in the opposite direction.

2. How high will it now ascend? Educe that as gravity accelerated it when moving downwards until velocity overcame it, so now gravity will retard it until in turn it overcomes velocity. Infer that the backward motion is due precisely to the same forces as the forward one.

3. How long should this continue? Infer that as the same causes are always in operation, apparently it should go on for ever. Does it? No, at length it stops. How is this? Bring out that it cannot stop of itself. If it stops, there must be some force to stop it. State that it would oscillate longer in the exhausted receiver of an air-pump. Infer that air opposes it. Show also the influence of friction

at the point of suspension. Tell that the weight in a clock is to overcome these.

4. How does a pendulum measure time? Draw a diagram so that A may represent the point of suspension, A B the pendulum, and C D the arc described in one movement. Now revise so that the children may state that the forces acting on B in producing the motion from C to D, being precisely those which produce the motion from D to C, the time of moving from D to C must be equal to that in moving from C to D. Now proceed to show that if the time of this movement was determined, and the number of vibrations recorded, we should have an accurate measurer of time.

76.—Compensation to Animals for Winter.

I. Develop the notion of compensation.

Ask for differences between summer and winter. In the latter, less heat, and light for a shorter period. This is a state of deprivation. Refer to the spider. It lives on flies, but cannot fly. It wants a power which the fly possesses, but it has another instead. It can weave a web. Give other instances, then give the term compensation. If then any animal has something for that of which winter deprives it, there is compensation. Let us see.

II. Compensation to man. Compare man with the inferior animals. Many of the wants of these provided for. Give instances. Man has the power to provide for himself. This is compensation.

1. Take a cold day. The chill felt is from the cold air taking the heat from the body. Bring out by instances and experiments that there are substances through which heat does not pass rapidly, as, for instance, soot at the bottom of a kettle. Now suppose a non-conducting substance to be placed between the body and the air, what would be the result? Such then is the effect of clothing. But how could man know this? It must have been a discovery. The power to make such discoveries is a compensation.

2. It might also be shown that man has the power to produce heat by artificial means; and that he has discovered that certain foods supply more heat than others.

III. Compensation to inferior animals. 1. *Some escape by migration.* Bring out that though man has the *power to protect* himself, or to provide for the future, the

lower animals have not. How do they escape the severities of winter? Refer to the wren, sparrow, and robin. These leave the woods and come to the abodes of men. Swallows leave the country. The snow bunting comes to it. By such instances as these show that rigour of climate is often escaped from by migration.

2. *Some are protected by a change in their clothing.* Draw out that many animals do not migrate. What provision is made for them? Refer to the cat. Point out the difference in its coat in the winter. It is thicker, has more fur. Give other instances so as to show that in some fur, in others wool, in others down, thickens as winter approaches. Again, notice the difference of radiating power between white and black. Black dresses allow the heat to pass readily. What colour then is best for winter? State that as we proceed northwards we find the colour of animals as winter approaches changing to white. Instance the ermine, polar bear, and others. So, then, some animals have compensation in the thickening of their coat, others in the change of colour.

3. *Some pass into a state of torpidity.* Some animals do not migrate, nor is there a change in their dress. How do they escape the rigour of winter? They become torpid. Where is the compensation? Educe that all animals require sustenance. During the torpid state they cannot seek it. State that the animal on entering the torpid state is very fat, and when it awakes is very lean. Infer that the fat served the purpose of keeping up its temperature. Point out that if there were not heat the animal would be frozen to death, but the temperature of its body never descends below that of the air. Notice, too, that if the temperature becomes very low the animal wakes and seeks food. Point out also that when such animals wake they are diminished in weight, but not in strength.

77.—The Syringe.

I. Parts. Show a glass syringe, and a metal one. Notice that there are two chief parts,—a barrel with a small tube at the end, a piston and its rod.

II. Principle. 1. Draw up the piston, then insert the nozzle in water. How high does the water ascend? How

is it that it does not ascend to the level of the water outside? Contrast with the water in the spout of a teapot. Also invert a wine-glass over a bit of white paper in water and press down. Infer air resists. Two things cannot occupy the same space at the same time. Give the term impenetrability.

2. Keep the nozzle in the water, then press down the piston. Observe the surface of the water during this action. What takes place? Bubbles appear. How are they caused? Infer that air is escaping.

3. Keep the nozzle in the water. Draw up the piston. Can air get into the barrel? How is that? What does take place? The water ascends till the barrel is filled. How can you account for this?

(*a*) Tell of the well in Tuscany, and what Galileo is reported to have said. Many people now say that the piston sucks up or attracts the water. How shall we find out? Apply the piston by itself, the water does not follow. Insert a glass tube in water, and draw out the air with the mouth, the water rises, but there is no piston.

(*b*) What then? Fill a wine-glass with water, cover it with paper, and invert. How is it the water does not fall out? Weigh the glass, then weigh the glass and the water, what will the difference represent? The weight of the water, and this weight is pressing on the paper. How is it the water does not fall out of the inverted glass? What is there all round? Air. It must then be air pressing against the paper. Insert a knife between the paper and glass so as to admit air. What takes place?

(*c*) Put the question again. What causes the water to ascend in the barrel? Infer that air is pressing on the surface of the water all round the syringe. Show—

1) That water yields to pressure.

2) That pressure on water is conveyed through the water in all directions.

3) That if the pressure was one pound to a square inch, there would be a pressure of one pound on every square inch of the vessel.

4) Educe that where there is nothing to resist the pressure, there the water will force its way as long as the pressure continues.

5) Now elicit that in the nozzle there can be no resistance, because the air has been expelled. Infer that the

water ascends because of the pressure of the air. Give the amount of pressure, nearly 15 lbs. to the square inch.

(*d*) Go through the process by which Torricelli and Pascal established this. Water ascended in the pump at Tuscany 32 feet, then Torricelli reasoned that as mercury is about 13½ times heavier than water, mercury in a tube would stand proportionately lower. How much? Torricelli tested it, and found it was so,—that when water stood in a pump at 32 feet, mercury stood in the tube about 28 inches. Pascal reasoned that if it was due to the pressure of the air, that pressure must decrease as you ascend; that if you took the tube of mercury up a mountain, the column would sink as you ascended. He tried it, and found it was so.

4. Take syringe full of water and hold it downwards. Does the water run out? How is that? If it does, what does that show? What do lads do to make it air-tight?

78.—Animal Heat.

I. Heat. Explain the term. Show that we use the term both for cause and effect,—for the substance or force, and the sensation. This often leads to mistakes. Give the term caloric for the substance. Caloric is in the human body. Our lesson is to discover how it is produced and sustained.

II. Combustion. Draw attention to breath, and how it differs from air. Give the constituents of both. How are those of breath produced? Notice that they may be produced by combustion. Illustrate by the burning of a candle. Show that the union of oxygen and carbon under certain conditions is to evolve heat. The air contains oxygen, the body contains carbon; if these can be made to combine, heat will be evolved. Show also that wherever oxidation takes place heat is given off, and that in the body this is constantly going on.

III. Process in the lungs. Carbon, hydrogen, and other substances are diffused through the body; we want to bring oxygen into contact with them. How is it done? Refer to the function of the heart and lungs. Let us examine a cell in the lungs. Let us suppose one magnified as big as an orange. We observe three tubes. A small pipe from the windpipe conveys air, another conveys dark blood, and a third takes away bright red blood. Here there is a

change. The blood comes to its vessel *dark*, and leaves it bright *red*. How is the change produced? We have seen that air contains oxygen, the dark blood contains carbonic acid and iron. By reference to rust on iron show that iron attracts oxygen, and there is a union of the two. Carbonic acid and hydrogen are separated from the blood and expelled, and the oxygen in union with iron enters the blood. Now infer that the change is due to the expulsion of carbonic acid and to the presence of oxygen. Illustrate by dark blood exposed to air becoming red.

IV. How THE OXYGEN IS DISTRIBUTED. Describe the function of the heart as a force-pump. The blood containing oxygen is conveyed to the heart, and by it sent through the body. Now carbon, hydrogen, and other substances are diffused through the body, and wherever oxygen comes in contact with them they are oxidized, and heat given off into the blood; thus the temperature of the blood is raised, and as it is carried along it raises the temperature of other parts, so that the blood becomes like a circulating warm water apparatus would be to a house.

V. How IS THE FIRE KEPT UP? It might be shown that in every muscular or mental exertion some effete portion of muscle or nerve is thrown into the blood. That thus many things find their way into the blood which would be injurious if not disposed of. That many of these are first oxidized, thus contributing to the heat of the system, and afterwards excreted. But as there is thus constant waste, there must also be constant repair. This the office of food,—some foods conveying to the blood heat-giving matters only.

VI. Work out that a difference should be made in heat suppliers according to the season. Point out that as fires may die out under too much fuel, so there may be too much in the body. Show that exercise, by quickening the breathing and the circulation, will raise the temperature, and get quit of the surplus quantity. Point out how heat escapes in perspiration, and how the air acts in modifying the temperature of the body.

79.—On Making Tea—a Lesson for Girls.

I. Introduction. Place two teapots before the class, one *earthenware*, the other metal. Which material is best for

a teapot? Elicit that is the best which best answers its purpose. The purpose here is to produce good tea.

II. WHAT HAVE WE TO DISCOVER? In which we can make the best tea. Ask for the kind of water used. Suppose that boiling water was poured on some tea, and hot water, but not boiling, poured on an equal quantity of the same quality of tea, which would produce the better tea? Then educe that the greater the heat is, the better the tea.

III. LENGTH OF TIME. By reference to facts show that tea is better from standing some time than if poured off immediately. Infer that the longer the action of the heat, the better the tea.

IV. TEAPOT MUST RETAIN THE HEAT. Suppose that of two teapots one retained the heat longer than the other, in which of them could we make the better tea? Draw attention to the radiating power of metal and earthenware. Be prepared with appropriate facts. Then infer that as metal retains the heat better, it would be the best for preparing tea in.

V. BLACK EARTHENWARE. Draw attention to some old women's preference for black earthenware teapots. Show that black is a good radiator. Infer that a black teapot would be a bad one for making tea in. Yet old women like good tea. Point out that black absorbs heat readily and that old women place their teapots on the hob near the fire.

80.—THE DAVY LAMP.

I. INTRODUCTION. Name the subject of the lesson. Gather from the class their knowledge of the dangers attending coal mines, especially from explosive gas.

II. CONSTRUCTION. In the absence of a lamp, draw a diagram on the black-board. Explain that it consists of a lamp placed in a cage of wire gauze. Ask for the mode of regulating a common lamp. State that the Davy lamp is used to prevent explosions. Could that be the case if the flame were exposed while regulating the lamp? Show that the screw to regulate the lamp is underneath.

III. PRINCIPLE. 1. Elicit the consequence of entering a room in which gas had been escaping, with a lighted candle. There is no explosion till the gas comes in contact with the flame. Now describe a coal pit largely filled with an explosive gas. If a lighted candle were taken in, so that the

flame came in contact with the gas, what would happen? Show that by using common lamps, from the necessity of admitting air to the flame, gas has come in contact with the flame, and there have been explosions. But a man may go in with a Davy lamp and yet there be no explosion. How is this? Some of the boys may answer that the gauze prevents the gas entering the lamp. Work this out. Have a piece of gauze and a lighted candle, place the gauze on the flame. The flame does not pass through, but smoke does. Infer that the gauze-wire will not prevent the gas entering the lamp. How is it then that it does not explode? Illustrate by a light applied to a sprinkling of gunpowder and to a large quantity; there is an explosion in the latter case. Is there in the former? Apply to the small quantity of gas in the lamp, and state that it does burn with a bright blue flame.

2. How is it the flame does not pass through the gauze? Recur to the former experiment. Place the gauze on the flame. What happens? The flame does not pass through the gauze, but smoke does. What is this smoke? Apply a light above the gauze, it breaks into flame. Now how is it the flame does not pass through? Perhaps a boy may say that the holes are too small. Deal with the answer so as to show that is not the fact. Recur again to the question. Show by proper illustrations that gas requires the *heat* of *flame* before it will light. Then compare metal with other substances so as to elicit that metal rapidly conveys heat, or is a good conductor. From this infer that sufficient heat to light the gas outside does not remain.

3. Metal becomes red hot. Perhaps a lad may suggest that metal by continually receiving heat may become red-hot. Will there not be an explosion then? Recur again to the experiment with the gauze. Take a match, light it, let it burn a little, blow out the flame, the end is red-hot, apply it to the gas. Does it light? State that gas requires the heat of flame before it will light. Metal must become white-hot before it will have this effect. What ought a miner to do if the wire of his lamp were to become red-hot?

4. What then is a Davy lamp? It is a protection by warning of danger. How does it do that?

81.—Teapot Spout and Lid.

I. The spout. Bring out that its top is higher than t'

level of the teapot. What is that for? Suppose one to be lower, say half as high. What would happen when water was poured in? How is this? If the spout were low you could not fill the teapot. How is this? Give facts and illustrations so as to educe and establish the following points.

1. Fluids yield easily to pressure.

2. Pressure is conveyed in them in all directions.

3. So long as there is no pressure in the spout to outbalance it the liquid must rise.

4. Infer that the water will rise to the same height in the spout as it is in the teapot. Illustrate also by syphon, and by pipes conveying water from reservoirs to houses.

II. Hole in the lid. 1. What is a hole placed there for? Perhaps a lad will say to let steam escape. Elicit that escape of steam would be an escape of heat. What would result? Is that desirable?

2. Refer to boy's sucker. How is it that the stone sticks to it? Give experiments to show the pressure of air. Infer that there is pressure of air in the spout. What would be its effect? Educe that if the pressure of the atmosphere exceeds the weight of the water, this cannot run out. What would be the pressure of the air in the spout? Show that this would depend on the area. But as the pressure is nearly 15 lbs. to the square inch, it must be a large teapot indeed where the weight of the water would exceed it. Refer to beer-barrel and to vent-peg. When this is up the beer runs. Now put the question again. What is the hole in the lid for? Recur to the facts established in the former part of the lesson, and infer that the pressure of the air through that tiny hole will be conveyed in all directions.

3. Put two test questions. As there is a pressure through the hole in the lid, how is it the water does not rise in the spout and overflow? The pressure in the spout balances it. When the teapot is held so that the tea runs out, what forces are acting in the spout? Two,—the pressure of the air through the hole, and the weight of the tea.

82.—Atmosphere.

1. *The term.* It describes the entire body of air. Why sphere? Suppose the earth to be taken away, and the atmosphere to remain, it would appear a hollow sphere with

[illegible] water. Show that it must take the shape of the [illegible].

2. [illegible]. Wave the hand, there is [illegible] and a [illegible]. But with an open umbrella [illegible]. You find it difficult to do so because of the [illegible]. Place a bit of wood on some water, invert a tumbler, the wood is below the level of the water outside, because the water inside is not on the same level. What does this show? Give account of the diving-bell. Notice other instances of resistance.

3. *Pressure.* Take water out of a basin the gap is at once filled up. To what is that due? So rarify air by heat—instance a fire in the street when gas-pipes are being laid down, and a cold current sets in. Describe a pump. Water ascends the barrel, then some force must be at work. The only possible force is the atmosphere. Give pressure about 15 lbs. (14·7) to the square inch. Refer also to barometer. Notice its oscillations, and infer that the pressure is not uniform. Oftentimes vapour is in the atmosphere in larger quantities than at other times. But vapour and air, bulk for bulk, are not of equal weight, the former being lighter than the latter. To what attribute the alterations of the barometer? By appropriate facts lead the children to infer that the atmospheric pressure decreases as we ascend mountains.

4. *Elasticity.* Have a football, formed of tough, flexible, but not elastic material. It is filled with air. Squeeze it, and then remove the pressure, it regains its shape. Illustrate this property by means of a popgun and of a pair of bellows.

5. *Conductor of sound.* Throw a pebble into a pond. What takes place? How far do they extend? State that as air is a fluid a similar disturbance would produce a similar effect. What would be the shape? As it would be in every direction it would be spherical. When this vibration reaches the ear, then there is sound.

83.—EVAPORATION.

I. INTRODUCTION. Suppose a shower of rain. It wets the pavement, and here and there are little pools. But in a short time the pavement is dry, and the pools of water have disappeared. Refer also to washing day, and to clothes put out to dry. How shall we account for this? Make clear

that the water must either sink into the ground, or be absorbed into the air; one or other or both. It is not destroyed.

II. CAUSES OF ITS DISAPPEARANCE. 1. *Heat.* Refer to wet clothes placed before a fire. What is observed? Vapour ascending, What happens to it? It gradually spreads and disappears. Place a dish of water in front of a fire; the water in time disappears, and much sooner than it would away from the fire. Infer that heat is the agent by which water is thus changed into vapour. How is it done? The children will be able to state from former lessons that heat expands things; that the particles of water are very small; that they are held together by a very slight cohesive force; that the heat acting on the water overcomes this force and drives the particles apart from one another. This is called evaporation. Now apply. What is the great source of heat? The sun is sending forth heat continually. Nearly three-fourths of the earth's surface covered with water. This water will absorb heat from the sun's rays. The surface acted on will be converted into vapour; where will be the greatest amount? When will there be most? Give facts respecting tropical seas, the Red Sea, and the Mediterranean.

2. *Air.* (*a*) From the illustration of clothes before the fire, water boiling, and similar facts, let the children state that this vapour is absorbed by the air; that this is the second great agent in evaporation. How is this brought about? Remind them of what takes place when sugar is put into water. The sugar disappears, but it is there. The water absorbs it. This illustrates the absorption of vapour by air. The air is like a great sponge.

(*b*) How does it ascend? Perhaps the answer will be given, "The sun draws it up." Refer again to clothes drying before the fire. Where does the vapour go? It ascends. The fire does not draw it to itself. How is this? Give the common illustration of cork in water. How is it that the cork rises in the water? From other lessons the children will state that it is owing to the pressure of the water upwards. That bulk for bulk, water is heavier than cork, and sinks; and as its pressure is in all directions, it forces the cork up. How quickly the force acts! Apply to air. Bulk for bulk, vapour is lighter than air. What will the air do? What effect will this have? Then the

vapour ascends because it is displaced by the descending air.

(*c*) How high will it ascend? Revise the action of heat in converting water into vapour. Show that by lowering the temperature the vapour may be turned again into water. Elicit the fact that the air becomes colder as its distance increases from the surface of the earth. Infer that the vapour will ascend so long as the temperature of the air is not below its own. Give the estimated height inappreciable at the height of five or six miles.

(*d*) How much will it hold? By the illustration of air-pump show that its capacity depends greatly on its density. Give also the fact of water boiling on a mountain at a lower temperature, owing to the alteration in the density of the atmosphere. Show also that its capacity is affected also by its temperature. Hence infer that the amount will be a varying quantity according to these conditions.

III. CONDITIONS OF EVAPORATION. 1. *Heat of Atmosphere.* Show that when the atmosphere is very cold, it will take away some of the heat from the water, and thus decrease the vapour-making force. Hence infer that there will be less evaporation at night, and much less in winter, although there will always be some evaporation. Referring again to the capacity of the atmosphere for vapour as affected by temperature, infer that in a high temperature there will be more evaporation. What are the conditions in this case? Greater vapour-making force, greater capacity for vapour.

2. *Gentle winds.* Refer to clothes or water drying quickly in a gentle breeze. How account for it? What is wind? Then in a gentle breeze the air is continually changing its place, and fresh air comes into contact with the water. Suppose some water shed on the ground, and you wanted to remove it. You have a large sponge full of water, and several small dry pieces,—which would you use? So when the gentle breeze comes against the clothes, or rolls over the water's surface, it is just as if dry sponges were applied.

3. *Saturation.* Suppose the air to be very moist, what effect will that have on evaporation? Refer again to the illustration of sugar and water. The water can take in *only* a certain quantity, so with the air. When the air is *full it is said to be saturated.*

84.—Dew.

I. Introduction. An early morning walk in summer or autumn. What is seen glistening on the grass, on the leaves, all around? Dew. Where has it come from? The morning is bright, there are no clouds; the night has been clear, there has been no rain. How account for it?

II. How formed. 1. *Atmosphere contains vapour.* Examine class on evaporation. Elicit that the atmosphere contains vapour. That its capacity for vapour is increased by heat. That after a clear, hot day, the atmosphere would contain much vapour.

2. *Cold condenses vapour.* Speak of the vapour issuing from the spout of a kettle containing boiling water. Place a cold plate over it. What occurs? How is this? What would you find the vapour to be if you put your hand in it? So hot as to scald you. But the water on the plate is very much colder. What has the vapour lost? How? The plate must have absorbed the heat. Infer that the vapour condenses into water because the plate deprives it of its heat.

3. *Radiation of heat from the earth.* (*a*) Elicit that the earth is heated from the sun. The sun's rays pass through the air, but the air is heated by the earth. How can this be shown? Which part of the atmosphere has the greatest temperature? (*b*) Refer to the radiation of heat. Some bodies radiate heat more quickly than others. The earth radiates heat. But in the day it receives much more than it loses. What will take place when the sun sets? Infer that the temperature of the surface will be lowered, and that some objects will be colder than others.

4. *Cold substances on the surface extract the heat from the atmosphere in contact with them.* Bring out that the vapour and air do not part with their heat so readily by radiation as the earth does. Infer from facts given before that they part with it quickly when in contact with bodies colder than themselves. Elicit that as the earth parts rapidly with its heat after sunset, and some bodies more quickly than others, and become of a lower temperature than the atmosphere, they will extract the heat from the vapour immediately in contact with them. What will take place then? The vapour will condense on the surface

5. *Dew-point.* Lead the class to infer that dew never begins to form on an object till the object is colder than the air and the vapour near it. That as these objects extract the heat from the atmosphere, there is a point of temperature when dew will begin to form. This is called the *dew-point.* Now test the intelligence of the subject by asking —How is it that when we breathe on a slate its surface becomes damp? How is it that a bottle of cold water brought into a warm room is soon covered with moisture.

III. CONDITIONS UNDER WHICH FORMED. 1. *State of the atmosphere.* (*a*) Elicit that a favourable condition is after much evaporation. Infer that there will be better conditions in hot countries for dew. Give the facts. (*b*) Point out the effects of clouds. They reflect the heat back to the earth. On a clear night there is no impediment to radiation. On which night will there be the lowest temperature? What effect will this have on the atmosphere? Its capacity for holding vapour will be lessened. The earth also parts with its heat to a greater extent, therefore there is more dew. (*c*) On which night will there be most dew, on a clear tranquil one or a windy one? Lead the class to infer that on a windy night the cold object and the vapour are not long enough in contact for this to be condensed.

2. *Substances that are easily bedewed.* Elicit the fact that more dew is found on grass, and on leaves, than on rocks. How account for this? Such substances radiate heat more quickly. Point out the beautiful provision in this. Vegetation receives the moisture that it needs.

3. *Covered or shady spots.* Not so much dew on these. Let the children explain this. Infer that there is little dew in a wood. Point out that there is not as much evaporation, hence dew is not needed. There is no waste of the Divine resources.

85.—CLOUDS.

I. INTRODUCTION. Examine on evaporation and dew. Elicit that the atmosphere contains much vapour. Sometimes much more than at others. That where the air is dense there is less vapour, hence the air near the surface contains less than at a distance from it.

II. FORMATION OF CLOUDS. 1. *Vapour slightly condensed becomes visible.* Refer to steam issuing from the spout of a tea-kettle. Elicit that just in the mouth of the spout it cannot be seen, or is invisible, but at a little distance it can be seen. How is this? What has it mingled with? What has this done? Then cold air slightly condenses it, and it becomes visible.

2. *Currents of air.* Elicit that the higher strata of air are much colder than the lower. Let them state the effects resulting from this, especially in hot regions. Draw out that the currents of air so formed will differ in temperature and in amount of vapour. Lead them to infer that when a cold current meets a current of higher temperature loaded with vapour this will be condensed. What then? It will become visible, or form a cloud.

3. *Mists.* Ask for facts concerning these, which the children may have observed. Test their intelligence of the formation of clouds by asking them to account for the formation of mists. Lead them to infer that a mist differs from a cloud only in its position. Let them also state how it is that clouds are more commonly formed than mists. The upper strata contain more vapour, and are more liable to cold currents.

III. USES OF CLOUDS. 1. As means of conveying water over the land. 2. As screening from the heat of the sun. 3. As arresting and reflecting heat at night. 4. As a vehicle for electric fluid. 5. As objects of beauty or grandeur, and as giving rise to pleasant scenes in the landscape.

86.—ATTRACTION.

1. *Give the notion.* A stone unsupported. What happens? Rivers run downhill. How *run* at all? There must be force.

2. *Attraction is exerted by bodies in all directions.* Place pieces of chip on a dish of water. What takes place? They approach each other, or in other positions would approach the sides. They do not remain where they were placed. Give other instances. On a large scale we see it in the tides. How?

3. *Attraction is according to quantity of matter.* Place a large and small cube on a dish of water. What takes place? What difference in their rate of motion? The

small one moves faster than the larger one. Place chips of unequal size, and each piece thicker at one end than at the other. What do you observe? The thicker parts approximate the most rapidly. Suppose you let a stone fall out of your hand, what will be its direction? From the illustration just given lead them to infer that it will be towards the centre of the earth. Test their intelligence by supposing a hole through the earth, and a marble dropped. Where would it finally stop? Give other illustrations. Water poured out of a cylindrical cup, and out of a jug with a projecting lip. What difference is observed? How account for it? Notice also dew drops, globules of water, shot. What form do they take? How is this?

> "That very law which moulds a tear,
> And bids it trickle from its source—
> That law preserves the earth a sphere,
> And guides the planets in their course."

4. *Attraction is according to distance.* Refer to bodies falling from a height; to a floating substance as it nears the bank. Give the law.

5. Test intelligence by asking, what is weight?

How is it that 100 atoms are 20 times heavier than 5?

87.—Spirit Level.

1. *Exhibit a spirit-level.* What is it? What is its use? How does it show this? Let the eye be applied to the level. The glass tube is slightly curved. How is that?

2. *Have a dish of water.* Look at the surface. What do you say it is? Smooth and level. What do you mean by level? That it is flat or a plane. Is it so? Elicit that the particles of a fluid are easily displaced; so that were a force acting on one more than on another, what would happen? It would be displaced. What force is acting on the water? That of gravity. Bring out that it acts on every particle. Infer that all the upper particles will be at the same distance from the centre of the earth. What then will be the shape of the surface? Apply to the spirit level, and infer that the surface of the fluid at rest does not form a plane, but is slightly curved.

3. *Take another illustration.* Suppose a vessel of water, and a cupful taken from it. How is it there is no hollow?

Draw a diagram to represent the water before rushing in to fill the hollow. Take two particles of water on the same level, one in the deeper part, the other under the hollow. Elicit that the forces acting on these particles is as the depth. Hence, that in the deeper part, as the pressure is in all directions, it will act until the other one is made to rise. So with all the others, until the hollow is filled, and the surface smooth.

4. *Place the spirit-level on a perfectly horizontal plane.* What will take place? Examine so as to bring out that in consequence of the force acting on the fluid, the air bubble will rise to the highest part. Which is that? The centre of the arc.

88.—Annual Motion of the Earth.

I. Earth's orbit. 1. *The problem to be solved.* The earth was to be so placed and moved as to go round the sun. How could it be accomplished? Let the difficulty be conceived, and curiosity aroused.

2. *Attraction.* Bring out that the earth must be placed where the sun would attract it. But if this only was done, what would happen? The earth would fall into the sun, as a marble allowed to drop falls to the earth.

3. *Impulse.* By means of a globe and marble show that the earth at the instant of being placed within the sun's attraction, ought to have an impulse at right angles to it. Suppose this done, what then? There would be two forces acting on the earth. How would it move? Let this be illustrated till thoroughly comprehended.

4. *Continuance of attracting force.* Bring out that the sun's attraction is constant. What is the inference? The earth ought to approach nearer and nearer to the sun. How is it that it does not fall to the sun?

5. *Velocity.* Show that as the earth approaches the sun, its velocity must increase. Show how this increased velocity will tend to send it off at a tangent. Lead to the inference that the orbit is elliptical. Hence we are nearer to the sun at one time than another.

6. *Nearness to the sun.* Illustrate the varying distance of the sun from us by reference to its apparent diameter at different times of the year.

II. Continuance of the earth's motion. 1. *Velocity overcomes gravity.* Let it be made clear that as the earth approaches the sun, its velocity will become so great as to overcome the attracting force, and carry it gradually away.

2. *Diminishing velocity.* Proceed to show that as the distance from the sun increases, the velocity will be diminished, until at length the attractive force overcomes it, and the same course is pursued as before.

89.—Rainbow.

1. *Light falls on rain.* All have seen a rainbow, and admired it. Elicit the facts observed. Educe that light is falling on the raindrops. How account for the colours seen?

2. *Refraction and reflection.* Recall former lessons on these points. Bring out that when light passes from one medium into another it is refracted, or bent. Changes its direction. Also elicit that rays of light falling in some circumstances are reflected.

3. *Apply to falling rain.* If rays of light fall on these, and enter them, what will take place? They will be refracted. Elicit also that some of the rays will be reflected, so as to reach the eye of the spectator. Show that the reflection may take place from the outside of the drop, or from what we may call the inside of the film. At present we have only to do with the latter. Place a diagram on the black-board. Let a circle represent a drop of rain, and let a line meeting it represent the ray of light. Show the refraction that would take place on entering the drop. Show also the reflection that would take place from the concave film. How would these proceed? Show also that on leaving the drop they would be again refracted.

4. *Colours.* Recall the lesson on the prism. Elicit the direction of the falling ray, and how it strikes the surface of the prism, and the reflection of the colours that ensues. Apply to light falling on a raindrop. Evidently some will so enter the falling drop as to be broken up into their constituent rays, and these will be reflected.

5. *The eye.* Suppose a ray of light thus to be broken up. How many of these colours will enter the eye? As the *colours possess* very different degrees of refrangibility, and

consequently diverge very much, it is evident only one would enter the eye. How account, then, for the eye taking in all the colours? Point out that many rays fall simultaneously on the same drop. From these rays, according to their position, several of the reflected colours, perhaps all, may enter the eye. Elicit also that there are many drops in close proximity, and that which is true of one is true of all.

90.—Physiology.—Living Bodies.

I. Introduction. Ask for natural objects. Distinguish between natural and artificial. All natural objects belong to two classes—animate and inanimate. Take any mineral. Every particle exhibits the same properties as those possessed by the whole; these are the inanimate or inorganic bodies. But that is not true of animate bodies. Here the structure differs, according to the office it has to perform.

II. Properties of living bodies. 1. Put a pebble and a potato in soil in the spring. Let a few weeks elapse and visit them. What is observed? No change in the pebble, but in the potato, decay, a radicle, and a green shoot. Wait some time longer, there are other changes; and at length other potatoes. In the pebble there has been no change, but in the potato a series of changes. So with other things. To what are these changes due? We term these changes vital actions, and we attribute them to a vital force, and we say of the potato that it has vital properties.

2. Go into a garden when fruit is just appearing, and again a few weeks later; the fruit has increased in size. It has grown. What do you understand by that? It has drawn fresh material and converted it into its own substance. How? Each part of the fruit has power thus to act on substance brought to it. This is what we call organized structure, and this act is the manifestation of a vital property.

3. A man works hard. In doing so he puts forth mechanical force. You can tell me how he appears. Hot. Yes, he has given forth heat. He also perspires. This perspiration is composed of water and carbonic acid. These have been separated from the blood by the skin. Thus the man has lost substance and weight. Show that the same thing is going on continually, only in a less

degree, even in a quiet state. This is another manifestation of vital force, and these are termed vital actions.

4. Suppose this waste to go on. What then? The body would dwindle away. What craving comes to prevent this? Show that the means of producing heat and of repairing waste must be continually supplied. Living bodies draw materials for their growth and repair from other bodies. Such bodies are called food. Show that food is not nutriment, but is converted into it. Show also that the food when taken has no vital properties, but it becomes endowed with these in becoming part of the structure of the living body. The force that does this is vital force. It works through organized structure.

5. When a body is deprived of life it rapidly grows cold. It also decays; that is, it separates into the elements of which it is composed, that which held them together having disappeared.

91.—The Human Body.

I. Introduction. Examine on the distinction between organic and inorganic bodies. Elicit the characteristics of vegetable life. Ask for the particulars in which animals resemble vegetables, and in which they differ from them. Apply to man. In man there are two kinds of organs—those similar to vegetables, those belonging to animals—the former, termed those of organic life; the latter, those of animal life.

II. The Build of the Human Body. The obvious divisions of the body, head, trunk, and limbs.

1. *It is erect.* (*a*) Compare with other animals. It differs in this respect from all. What animal comes nearest in its shape to man? Show a picture of the skeleton of a monkey. How does it differ? Show the folly of those habits and practices which cause the body to bend or stoop. Infer that anything that disfigures its beauty or injures its health is to be avoided.

(*b*) To what is the erect form due? Show a picture of the skeleton. Point out the poise of the head, the position of the shoulders, the shape of the spine, and the arrangements of the lower extremities. Show how all are held together by ligaments. State that the muscles help to keep it erect. The skeleton contains 200 bones.

2. *It is dual.* (*a*) Suppose the body to be cut into

halves by a line passing between the eyes, down the nose, and down the middle line of the spine, these parts would be found to correspond. Ask the children to give instances,—such as the ears, eyes, nostrils, arms, and legs. State that the brain and spinal cord may be separated into two similar parts. Point out also the lungs, kidneys, and dual arrangement of the heart and its vessels, the arteries and veins.

(*b*) By means of a diagram, show that the trunk and head consist essentially of two tubes, canals, or cavities.

1) *The dorsal canal.* Give the *root* of term dorsal (*dorsum*, the back). Point out that there is a chamber containing the brain, and a tube proceeding from it containing the spinal cord. The former protected by the skull, the latter by the vertebræ of the spine. This canal sometimes called the neural canal (*neuron*, a nerve).

2) *The ventral canal.* It consists of the face, the thorax, and the abdomen. It contains the organs which convert food into blood, circulate the blood through the body, and separate from it whatever is useless or hurtful. It has been called the hæmal canal (*haima*, blood).

92.—The Head.

I. Introduction. Examine on the former lesson. The present lesson to be on the head.

II. Its Position. 1. Ask for it. Where placed? Poised on a moveable pillar above the trunk. How poised? Suppose more weight on one side than the other, in front or at the back, what then? It would have a tendency to fall that way. Has it? Point out how nicely it is balanced.

2. Elicit that when a person sitting falls asleep, the head droops. How is that? Point out that the head is not always kept erect. How is it kept in its place? By strong ligaments and muscles.

3. Refer to the motions of the head. It is so poised that it can move backwards, as in looking up; or forwards, as in nodding. How is this? Explain how it rests on the atlas, or first vertebra of the neck. Refer also to the power of turning it partly round. State that when this takes place the atlas moves with it, on the second vertebra, the axis.

III. Its Parts. From the former lesson, the children will give the parts cranium and face. Ask for the facts.

Get the covering of the cranium, and the distinguishing features of the face. The head is formed of twenty-two bones.

93.—The Cranium.

I. Introduction. Show a picture of the head, and put the subject of the lesson clearly before the class.

II. What it is. 1. It is a cavity containing the brain. Elicit some of the differences between man and other animals. These due in many respects to his brain. Infer that it is the most important organ. Point out its position. Show the relation of the forehead to the face. Point out that the greater part of the brain lies in the upper and forward parts. In lower animals there is a projecting face, and the brain behind it. Draw a diagram to represent the facial angle of man as compared with that of the monkey.

2. How formed? Explain that the skull is not of one piece Lead the children to infer that having such an important organ in its keeping, it ought to be very strong. It is composed of eight bones. Six of them by their union form a vault. Point out the advantages of such a shape. Give the names and positions of the bones. What other name has the frontal bone? Why called coronal? (*corona*, a crown). Because it forms the crown of the head. Describe the occipital bone. It forms the back part of the head, bends so as to form a part of the base of the skull, and has a hole through which the spinal column ascends. Point out the bones forming the sides or walls of the head. Called parietal (*paries*, a wall). Show the positions of the temporal bones; they contain the ears. Explain that the base of the cranium is formed partly by two bones. One is called the sphenoid (*sphen*, a wedge). It is inserted so as to wedge in and lock the bones of the skull and face. The other is called the ethmoid (*ethmos*, a sieve), because it has a sieve-like appearance. The holes are for the passage of bloodvessels and nerves.

3. How joined? Describe the mode. Not by straight lines, but by saw-like edges. Compare with dovetailing. There is no motion possible. Separation is difficult. Point out the advantages of this arrangement.

4. Sort of bone? It is of the kind termed flat. These consist of two hard plates, with a soft substance between.

What is the advantage of this? Illustrate by the buffer at the end of a railway carriage.

94.—The Face.

I. Introduction. Examine on previous lessons. The present lesson to be on the face.

II. Its Parts. 1. Get the position of the face. To what divisions of the body does it belong? To the head, and to the ventral canal. Get the names and descriptions of the chief features. Point out that the face is often an index to the mind. Anger leaves its mark there. The eye often betrays the working of the brain. Give other instances.

2. Point out the cavities. There are five. The eye-orbits or sockets, the nasal cavities or nostrils, and the mouth. What organs do these contain? Those of sight, smell, and taste. These cavities are formed, and their organs protected, by the bones of the face. Of these there are fourteen—all of which are immoveable except one.

3. State that most of these bones are in pairs. In all possible cases let the children indicate their position. Ask for the two malar, or cheek bones; and the two superior maxillary, or upper jaw bones. The latter forming part of the roof of the mouth. Show the positions of the lachrymal bones (*lachryma*, a tear). How so called? State that they are channelled to convey tears from the eyes to the nose. Called the lachrymal ducts. Let the children touch the two nasal bones. State that besides these there are two small bones connected with the nose internally, called turbinated bones. Give the name of the bone forming the base of the nose, and separating its two cavities. The vomer or ploughshare bone. How so called? Let the class point out the inferior maxillary, or lower jaw-bone. It differs from the other bones in what respect? How is this movement provided for? State that at the back part of the mouth, and partly forming its roof, there are two bones called palate bones.

95.—The Mouth and Pharynx.

I. The Mouth. A cavity containing organs that act on the food.

1. *Ask for the teeth.* Small, hard, and white, all of one

length, and close together. Not all alike. There are three kinds: incisors, canine, and molars. In childhood, not so many as in later life. The child has twenty, the man has thirty-two.

2. *The mouth also contains the tongue.* This is a muscular organ supported beneath by the hyoid bone. Elicit a few of the facts respecting it. It can be protruded, shortened, curved up, or turned round the mouth. A little instrument very quick in its movements, and capable of changing its shape. It is very useful in rolling the food, and in swallowing. Its appearance often a guide as to the health of the system.

3. *Refer to saliva.* It is a fluid, colourless and tasteless. Where does it come from? It is produced by three pairs of glands termed the salivary glands. It moistens the food, and thus renders it better for swallowing. It also acts chemically on some portions of food.

4. *The top of the mouth called the palate.* Formed in front by a part of the upper jaw-bones, behind by the palate bones.

II. THE PHARYNX. 1. It is the cavity at the back of the mouth. A sort of bag suspended beneath the base of the skull in front of the vertebral column.

2. Point out that the entrance from the mouth into this cavity is through an arched passage. This is termed the fauces.

3. State that several tubes open into the pharynx. Two of these may be got from the class; the gullet, or food passage, and the windpipe or air passage. State the relative positions of these. Give also the terms glottis and epiglottis, as connected with the air-tube.

4. Show that there are openings of tubes into the upper part of the pharynx. Referring to the nasal cavities, state that the openings of these in the pharynx are termed the posterior nares. State also that there are tubes from the ears called Eustachian tubes. Explain that this portion of the pharynx is closed in the act of swallowing by the fauces and uvula. What is that for? To keep the food out of the mouths of the upper tubes.

96.—THE TRUNK.

I. THE VENTRAL CANAL. Recall the parts: face, thorax, *and abdomen.* The two latter separated by the diaphragm.

This cavity contains, what organs? Those connected with the formation of blood from the food. What other name is given to it?

1. *Organs belonging to both.* State that there are certain organs, portions of which are found both in the thorax and abdomen.

(*a*) *The alimentary canal.* It begins with the mouth. The gullet or œsophagus continues it down the neck and thorax. It pierces the diaphragm. Its continuation in the abdomen is formed by the stomach and intestines.

(*b*) *Sympathetic cord and thoracic duct.* Point out their positions. Both pierce the diaphragm. The latter takes its name from the thorax. Point out also that besides these the great arteries and veins pierce the diaphragm.

2. *Thorax.* Also called the chest. How so? It is a cavity. Its base is the diaphragm. Its walls are the sternum, ribs, and part of the vertebral column. It contains the heart, a thick muscular organ, the centre of the circulatory system. It also contains the lungs, the windpipe and its branches. It contains also the great arteries and veins; and a great portion of the gullet.

3. *The abdomen.* Examine on what is already known. Describe the stomach. A large bag, something like a bag-pipe. Situated below the diaphragm. Point out the intestines. Give their length. About six times that of the body, hence from thirty to thirty-six feet. Point out the position of the liver. It lies to the right of the stomach; the smaller end of which it is over. The kidneys are in front of the vertebral column. In shape something like a French bean. Point out also the positions of the spleen and pancreas.

97.—The Spine.

I. What it is. 1. *A column.* Spine is the name given to the column of bones that supports the head. It is sometimes called the cerebral axis. By it all the other parts of the body are directly or indirectly supported.

2. *It is formed of thirty-three bones.* Of these, twenty-four remain distinct. As life advances the remaining nine form into two bones, the sacrum and the coccyx. The twenty-four are called true vertebræ. They form a pyramidal column, the base of which is on the sacrum.

3. *Divisions.* The bones are distinguished b
tion into cervical, dorsal, and lumbar. There a
the neck, twelve in the back, and five in the
two upper vertebræ of the neck are termed th
the axis.

4. *Shape.* The spine is not straight. The c
tion curves forwards, the dorsal portion backw
lumbar portion again forwards.

II. VERTEBRÆ. Each bone is called a ver
I turn). They are so placed and fitted to eac
allow a partial turning of the trunk. The v
several distinct but similar features.

1. *The body.* The anterior portion forms
the bone. The upper and lower surfaces have s
sions scooped out in them; the object of this
appear.

2. *The ring.* Behind the body of the verte
or hole, so that in the way the vertebræ are pl
is formed, in which is lodged the spinal cord.

3. *The nerve passage.* By means of notcl
raisings, loopholes are formed on each side of
the transmission of nerves.

4. *Processes.* At the back of the ring ther
pointed projection called a spine, or spinous pro
are two others, one on each side, called the tr
cesses. To these processes muscles are attac
neck the transverse processes are pierced by a
which an artery ascends to the cranium. I
there are on each side the articular processes,
which the vertebræ are joined.

III. THEIR UNION. Show the necessity of
bones securely. Explain the danger from di
from shocks. How is the danger avoided?

1. *Joints.* Ask for the number of articulat
Show how these help to form the bones in
State that each surface is lined with elastic

2. *Invertebral substance.* Explain that the
vertebra does not rest immediately on its fell
placed between each a disc of highly elast
This preserves the cord and brain from inju
ments and shocks. These discs get pressed d
so that a man is an inch shorter at night than
morning.

3. *Ligaments.* Point out on the diagram the bands of ligament by which the parts of the column are fastened firmly together.

4. *Muscles.* Ask for the muscles already given. State that from the base of the skull to the sacrum, on each side of the spinous processes, there are arched cavities filled with the muscles, whose office is to aid in keeping the body erect.

98.—Framework of the Chest.

I. Introduction. Elicit that the chest is a cavity, having at the back the spine, in front the sternum, and between these the ribs. Its base the diaphragm.

II. Sternum. 1. *Description.* It is a short flat bone, with seven depressions on each side. Looks somewhat like a short sword. It is broad and thick at the upper end. Thin and elongated at the lower one. The lower end tipped with cartilage, called the ensiform cartilage, (*ensis*, a sword; *forma*, shape).

2. *Its position.* Point out that it is near the vertebral column at the top; and that it comes obliquely forward. Show that by this means there is a gradual enlargement of the cavity of the chest.

3. *Its function.* That it affords some protection to the organs of the chest will be obvious from its position. Point out that the notches on each side receive cartilages from the ribs, and its upper end articulates with the right and left collar bones. To its anterior surface powerful muscles are attached, which act on the upper extremities.

III. The Ribs. 1. *Description.* (*a*) *Kinds.* Show from the diagram that there are twenty-four ribs, twelve on each side. Let the children discover that fourteen, seven on each side, are connected with the sternum; these are called the true ribs. Point out that the next three have their cartilages joined, these called the false ribs. Show that the eleventh and twelfth have their front ends loose, these called floating ribs.

(*b*) *Their shape.* Each rib is a curved thin bone. The head, the part nearest the spine, is thicker than the shaft. Point out that the convex portion is outwards, the concave inwards. The effect of this? Greater capacity to the chest, with an increase of strength.

(*c*) *Size and arrangement.* Point out that the upper ribs are small. They increase in size to the eighth, when they again diminish. What is the object of this arrangement? Gradually to increase the capacity of the chest. Other purposes are also served.

2. *How fastened.* (*a*) *Posterior ends.* Point out that all the ribs have attachments to the spine. Fastened to the head of each rib is cartilage. The other end of this is split into three portions. The upper and lower ends are attached to adjacent vertebræ, and the middle one to the invertebral substance between them. The spine thus forms a medium of support, or sort of fulcrum to the ribs.

(*b*) *Anterior ends.* Ask for the facts already given. The seven pairs of upper ribs are fastened to the sternum, each by its own cartilage. This cartilage is elastic. What is the use of that? It serves in breathing to enlarge the capacity of the chest. This cartilage is termed costal (*costa*, a rib).

3. *Movements.* The ribs are raised and depressed in breathing. The ribs and diaphragm form a mechanism that may be compared to bellows. The ribs are moved by two sets of muscles called intercostal. The outer set run from the rib above obliquely downwards and forwards to the rib below. The inner set pass from the rib above downwards and backwards to the rib below. The outer muscles raise the ribs, the inner ones depress them.

99.—The Extremities.

I. Introduction. Examine on the build of the body. The extremities form one of the main divisions. They consist of upper and lower. Each set may be divided into limbs and bases of support.

II. Corresponding Parts. Place them in a tabulated form on the black board.

Upper Extremities.	Bones.	Lower Extremities.	Bones.
1. Bases of support.		1. Bases of support.	
(*a*) Scapula	1	(*a*) Hip or haunch bone	1
(*b*) Clavicle	1		
2. *Limbs :—*		2. *Limbs :—*	
(*a*) *Arm—*		(*a*) *Thigh—*	
Humerus . . .	1	Femur	1

UPPER EXTREMITIES.	BONES.	LOWER EXTREMITIES.	BONES.
(*b*) *Forearm*—		(*b*) *Leg*—	
Radius	1	Tibia	1
Ulna	1	Fibula	1
		Patella	1
(*c*) *Hand*—		(*c*) *Foot*—	
Carpus	8	Tarsus	7
Metacarpus	5	Metatarsus	5
Phalanges	14	Phalanges	14

III. DESCRIPTION, &c. Ask for the number of bones forming the limbs, and their bases of support. The upper extremities sixty-four, the lower sixty-two.

1. *Scapula, or shoulder-bone.* Point out its position. State that it is a thin bone with thick borders. These termed costal. To these muscles are attached. Point out its attachments to the collar-bone. Show the position of the glenoid cavity. Let the children see how these arrangements secure freedom of motion to the arm and hand.

2. *Clavicle, or collar bone.* Show it. Let it be seen that it keeps the shoulder and arm apart from the chest, and thus helps to secure that freedom for the motions of the arm so necessary to the use of the hand.

3. *Hand.* Draw attention to the various particulars that make the hand so useful an organ. Point out the position of the thumb, and explain the advantages resulting therefrom.

4. *The lower extremities.* Remarkable for their length as compared with other animals. Evidently adapted to maintain an erect position. In consequence of their length the head is raised, and so a wider range of vision is secured.

5. *The foot.* Placed at right angles to the leg. The sole is concave, so that the whole weight of the body rests upon an arch.

100.—CELLULAR TISSUE.

I. INTRODUCTION. Explain that the body in its various parts is possessed of vital properties, manifests vital force, and performs vital actions.

II. VITAL ACTIONS. By appropriate facts show that there exists a system of waste and renewal. Ask for instances of

repair, as of cuts or torn skin. Refer to the facts of heat and sweat diffused over the body. Infer that each living part of the structure is an organ as much as the heart is. Hence each part has its own work to do. Refer to saliva, bile, sweat, to the formation of skin, muscle, and bone, to show the variety of the work done. How is this work done? What are the means?

III. CELLULAR TISSUE. Describe a cell. A little vesicle containing a fluid. Its wall a membrane. Explain germ. Not always in the cell, but sometimes forms a distinct portion of the tissue. The germ is believed to contain the vital force. State that the force in the germ acts through or by means of the wall of the cell. Its office various. Depends on the organ to which the cell belongs. Sometimes it separates things that are not wanted. In other places it separates that which is necessary for the renewal of the tissue of which it is a part.

101.—CONNECTIVE TISSUE.

I. INTRODUCTION. State that the body is not only covered externally, but that this covering extends over all the internal cavities. It forms a sort of double bag. It is a sheath to every organ.

II. SKIN. What is it? The external covering. Called the integument. Consists of two layers.

1. *Epidermis.* Also called cuticle. The outer surface of the dermis. Consists of scales which are constantly shed in the form of powder. Has no nerves. Destitute of blood-vessels. Forms a sheath to the dermis. Underneath it are pigment-cells, the seat of colour.

2. *Dermis.* Called also the cutis, sometimes the true skin. Dense and fibrous. Abounds in blood-vessels. Illustrate fact by referring to blushing, and to its bleeding freely when cut. It is very tender. Its office to separate water, carbonic acid, and urea from the blood. These passed out in the form of sweat.

III. MUCOUS MEMBRANE. This lines all the cavities that open on to the surface. As for instance, the mouth and nose. It is a continuation of the integument, but more delicate, much redder, more sensitive, and bleeds more freely. It is continued through the alimentary canal. It also lines the wind-pipe. It is composed of two layers.

1. *The epithelium.* The name given to that which continues the epidermis. It is a horny, insensible, and bloodless tissue. Elicit that it is moister than the epidermis. To what due? It is not so exposed to the atmosphere. Its office requires it to be moister to facilitate the passage of things along the tubes. Illustrate by reference to swallowing. How difficult this is when the mouth is parched?

2. *The sanguine layer.* The dermis is continued into a layer having like characters, but with more blood-vessels. It secretes a fluid called mucus—hence the name Mucous membrane. It is to this that the greater moisture of the epithelium is due.

III. Serous Membrane. This lines the cavities that do not open on to the surface. It surrounds certain of the organs. It secretes a fluid by which the movements of these organs are facilitated, Each lung is invested with a serous membrane called the pleura. The heart is invested by the pericardium, and the stomach, intestines, and other organs in the abdomen by the peritoneum.

IV. Synovial Membrane. The bones that form joints are surrounded at the ends by a membrane that secretes a fluid called synovia. This fluid acts like oil; it lessens friction.

V. Ligaments and Tendons. These are formed of connective tissue, but they are much denser and stronger. Tendons are the tough cords that join the muscles to the bones. Ligaments are tough cords and bands that unite the bones at the joints. The dermis and sanguine layer of the mucous membrane are made up of filaments which, when boiled, yield gelatine.

102.—Hair: Its Structure.

I. Introduction. Elicit that hair grows: hence may be compared to a vegetable. It has two chief parts—the root and the shaft.

II. *The root.* It is a sac containing a bulb and pulp. The sac is a follicle formed by inversion of the skin: hence its lining is of epidermis. At the bottom of this is formed a papilla, which develops into a dense portion called the bulb, and a softer called the pulp. The pulp is furnished with bloodvessels. It is that out of which the hair grows. The *root lies* deep in the skin.

III. *Shaft.* This may be divided into the portion in the skin, and the part external to it.

1. *The sheath.* The part in the skin is inclosed in a sheath. This sheath is not in close contact with the hair. When cold contracts the skin, the sheath is narrowed and elongated. This gives rise to the appearance called goose skin. As the sheath grows along with the hair, its outer edges on reaching the surface break off and form scurf. This is a healthy formation: seen on the head because of the greater amount of hair. It is to be removed by comb and brush.

2. *Sebaceous glands.* (*Sebum*, tallow.) A little below the surface, external to the sheath, are little oil sacs, one on each side. They have openings into the sheath. Supply the hair with a kind of natural pomatum. No other needed. Keep the hair well brushed, that these glands may be stimulated.

3. *Parts.* The shaft is formed of a central pith and two other layers. A good illustration may be given by means of a quill. The medullary portion is thought to have vessels, by means of which fluids ascend to the very points of the hair. Immediately surrounding the pith is a cortical substance of horny cells. There is also an outer covering of epidermis. The horny laminæ of this are ranged transversely, and overlap one another like the scales of a fish, only not with such regularity. Pass a hair through the fingers,—in one direction it is smooth, draw it through in the opposite one it is rough. Account for this. In consequence of these horny coverings, hair has great strength. Single hairs have supported weights varying from 8,000 to 22,000 grains.

IV. *Colour.* Elicit that the colour of the hair varies according to complexion. State that some say that a light iris is accompanied with light hair, and that as its colour darkens so does that of the hair. The colour is due to pigments unequally distributed in the pith. These give its colour to the cortical sheath. The colour is thought to vary with the nature of these pigments. Some are formed of minute portions of carbon. Dark hair contains much iron. The colour of the hair changes. It changes in age. It is changed by sorrow. Give instances to show rapid change produced by terror, anxiety, and other forms of fear. *These changes* prove that there is organized connection *from the roots* to the points of the hair.

103.—Hair: Its Growth.

I. *Mode.* Not like vegetables by fluids passing through their length, but by additions to the root end. Thus the hair is pushed forward. These additions vary in size. Affected by health and other circumstances. Hence hairs are not of uniform thickness, but have often interspersed thin patches.

II. *Composition.* It is allied to the epidermis. Its basis is albumen. It contains also carbon, lime, flint, sulphur, manganese, and iron. The proportions of these vary in hair of different colours. The disagreeable odour evolved during the burning of hair is due to the sulphur it contains. Some of the dyes used act on the sulphur. The change is not permanent. Refer to hair affected by a damp atmosphere. It becomes swollen and straightened. To what due? It has absorbed moisture. How is this? Refer to the action of oil in relation to water. Infer that there is a deficiency of oil: hence the salts and animal matter entering into the composition of hair are unchecked in their absorption of moisture. In ill health there are remarkable changes in its appearance. It becomes dull in colour, and lank and straight. The effects due to absorption of juice from the blood in an immature, ill-elaborated condition.

III. *Dimensions.* The hair is not cylindrical, but flattened. The more flattened the more curly. Its thickness varies. Hairs have been measured, taken from the same individual, and have varied from $\frac{1}{150}$ to $\frac{1}{140}$ of an inch. The average thickness of the hair of the head is $\frac{1}{400}$ of an inch. The amount of hair on the body is very great. Arrangements for its growth are found all over the surface, except the palms of the hands and the soles of the feet. The hairs of the head of different persons have been calculated. It has been estimated that the average number to the square inch is 1,000. There are, say 120 square inches of scalp. How many hairs will that give to the entire head?

104.—Nails.

I. Structure. Somewhat like hair. Formed of epidermic cells. May be pared in the free end without pain.

1. *Bed.* Let the nails be examined. Point out the very

fine white and red lines, and the ribbed appearance. In what direction do they run? How account for them? The dermis in the bed of the nail formed into delicate folds or laminæ. Very abundantly supplied with blood-vessels. Between these folds of the dermis are thin vertical plates. These two in alternate rows give the appearance of ridges and red and white lines.

2. *Lunula.* Direct attention to the pale part at the root end. Its shape. Hence lunula (*luna*, the moon). Under this the dermis not in folds. Fewer blood-vessels. The ridges formed by the vertical plates may be seen.

3. *Root.* It is embedded in a fold of the dermis. There is a free edge of epidermis which covers part of the lunula. This ought to be pressed back weekly. The roots of the finger nails are covered about one-twelfth of an inch, that of the thumb about one-eighth of an inch, that of the great toe one-sixth of an inch.

II. Growth. 1. *Thickness.* The nail is thicker at the free end than in the lunula. Hence it must grow in thickness from its bed. How obtain the material? Recall that the folds or laminæ of the dermis are very vascular. Hence much material for growth. The dermis secretes a fluid which forms into epidermic cells. It also keeps the bed of the nail soft.

2. *Length.* The fact of growing forwards well known. How is it accomplished? By a similar arrangement behind the nail as in its bed. Epidermic cells are added to the root. Hence the nail is pushed forwards. Here we see why the bed of the nail should be soft and yielding.

3. *Amount.* The nails of the hands grow four times faster than those of the feet. How verify this? By cutting at stated times and measuring the parings. A thumb nail measuring eight lines or two-thirds of an inch takes twenty weeks to grow. How much is that a week?

4. *Spots.* Children often get knocks on their nails. These disturb the process of cell-formation. The place is indicated by a white spot. School girls call them gifts. They foolishly look upon them as omens of good fortune. Thus they utter silly rhymes; as—

"Gifts on the thumb
Are sure to come;
Gifts on the finger
Are sure to linger."

Lads that have had such spots will tell that they move forwards. On measuring the distance from the free edge of the nail, they may calculate the time before they can reach it. Suppose one to occur in the middle of a thumb nail of eight lines, how long will it be before it reaches the free margin? Ten weeks.

5. *Groove.* State that during sickness or disease the nails do not grow so vigorously. Hence the portion of nail formed during the sickness is thinner. It forms on the surface a transverse groove. The breadth of this will be according to the duration of the sickness. A depression measuring two lines in width, How long was the sickness? Five weeks. What would be the width of a groove when the sickness lasted twelve and a-half weeks? Five lines.

105.—Muscular Tissue.

I. Description. 1. *Position.* On removing the integument and sublayer of fat we come to reddish flesh. Refer to the flesh found on a butcher's stall. It covers the entire skeleton. It exceeds any other portion of the body. On examination it is found to be fibrous. It is called muscle.

2. *Structure.* Muscle is fibrous. A muscle is a bundle in which smaller bundles are arranged parallel to each other. It is ensheathed in connective tissue. The smaller bundles are termed fasciculi. They also are encased in connective tissue. These fasciculi are found also to consist of smaller bundles, each enveloped in a sheath formed by a tough, elastic membrane, called the sarcolemma. These smaller bundles are termed fibres. Each of these fibres is composed of filaments or fibrillæ.

3. *Kinds.* Muscular tissue is of two kinds, striated and smooth. When the fibres just named are examined they look like strings of beads, and they readily break up into small discs. These give the muscle a striated appearance. Smooth muscle does not so break up, and has no sarcolemma.

4. *Contractility.* Muscular tissue is highly elastic. Its peculiar vital property is that of contracting under stimulus. It shortens in the direction of its axis, while it increases in its diameter. The fibre becomes shorter, but as its bulk

does not diminish, nor the parts become compressed, it becomes thicker. These contractions are not simultaneous through its whole length, but pass on in an undulatory manner. The bulky part of the muscle under contraction becomes hard and firm. A muscle is shortened in the act of contraction about one-third of its length. What will be the effect of this contraction?

5. *Bloodvessels and nerves.* Muscles are more abundantly supplied with capillaries, arteries, veins, and nerves than any other substance except the sense organs. But these do not enter the fibrillæ.

II. Offices. 1. *Voluntary and involuntary.* Muscle is the great motor agent of the body. Recall the distinction between organic and animal life. Elicit that the movements connected with the body are of two kinds, those of the organic and those of the animal life. Muscles connected with the organic life are not directly under the control of the will, hence termed involuntary muscles. State that the greater portion of the muscles are connected with animal life. These are under the control of the will. Hence are termed voluntary muscles.

2. *Hollow muscles.* By reference to the iris and to the mouth, show that there are some muscles which enclose a cavity or surround a space; these contracting, lessen the capacity of the cavity or the extent of the space. Refer to the action of these muscles in the arteries and in the alimentary canal.

3. *Muscles attached to bones.* There are upwards of 400 muscles in the body. Most of these are for the movements of the animal life, and are connected with bones. Such muscles have names given to their extremities and to the portion between. This is called the belly of the muscle. The extremity nearest the body is called the origin, the other the insertion. Each of these muscles has the connective tissue in which it is ensheathed, lengthened out into tendons, by which the attachment is effected. The tendon is tough, strong, and elastic. Some muscles in their origin separate into two, three, or more attachments. Thus the muscles of the arm, biceps and triceps, have respectively two and three. Many of the muscles and tendons connected with the bones have a strong investment, termed fascia, the office of which is to keep all the parts in their places.

106.—Bones.

I. Description. 1. *Kinds*. Bones have been divided into three classes. *Flat* bones, as those forming the skull. *Long* bones, as in the arms and legs. *Square* bones, as in the vertebral column. Bones are hard, moist, pinkish, living structures. They are covered with a fibrous, nutrient, vascular membrane called the periosteum.

2. *Tissues*. When long bones are dead and dried they are found to be hollow or tubular, like pipes. But when alive, these tubes are filled with a soft, yellowish, oily substance, formed chiefly of adipose tissue. It is called marrow. The tube that contains it is called the medullary canal. The solid portion of the bone consists of two tissues.

(*a*) *The outer tissue*. It is dense and compact. It is thicker in those parts exposed to strain.

(*b*) *The inner tissue*. This is formed of immense numbers of small plates of bone, interlaced with each other so as to form spaces or cells. These are called the cancelli. The tissue is called the spongy tissue. It enters largely into the formation of the flat bones, and of the extremities of the long ones.

3. *Blood-vessels*. When a bone is fractured it is found to bleed freely. Microscopic tubes pass from the medullary canal through both tissues, becoming finer and finer in the compact tissue. Openings to these canals may be discerned on the surface. They are called the Haversian canals. Surrounding these canals is a compact tissue, in which may be seen many minute dark spots. These are cavities from which fine dark lines pass in every direction; some communicating with the Haversian canals. The cavities are termed lacunæ, and the fine tubes canaliculi. By these means blood is supplied to every part of the bone.

II. Composition. 1. *Chemical structure*. Bone is a compound of animal and earthy matter. The former gives toughness and elasticity, the latter firmness, hardness, and strength. They are blended in every part of the bone.

(*a*) *Earthy matters*. The chief constituent is phosphate of lime, of which there are 50 per cent., of carbonate of lime there are 10 per cent. There are besides small quantities of fluoride of calcium, phosphate of magnesia, and chloride of sodium, amounting to about 6 per cent.

(*b*) *Animal matter.* Of this there are about 33 per cent. It is converted into gelatine by boiling.

(*c*) *Qualities.* By increasing the proportion of phosphate of lime, bone would become much harder, as seen in teeth, but would become brittle in proportion. Hence would not be so well adapted as at present to resist shocks and strains.

2. *Experiments*, (*a*) *Burning.* On putting bone into fire it becomes white as chalk, very brittle, and loses greatly in weight, but retains its bulk and shape. What has it lost? The animal matters have disappeared, and the earthy ones remain.

(*b*) *Macerating in acid.* By steeping bone in hydrochloric acid, sufficiently diluted to prevent its injuring the animal matter, yet strong enough to dissolve the earthy, the mass left will retain the shape and bulk of the bone, but will become soft, tough, and flexible. The radius so treated may be tied into a knot.

107.—Blood.

I. Vital Fluid. Suppose a blow on the nose, or a cut of a finger. What is observed? Blood issues from the vessels thus opened. What shall we say of it? It is a thick, viscid, hot fluid. Give its temperature. 98°. State its specific gravity. 1055. "Blood thicker than water" literally true. State that it is a vital fluid. What is meant by this? State that it is a fluid only so long as it lives.

II. Colour. This will be given. Point out that in some animals there is real blood that is not red. Blood in the cornea of the eye is not red. Hence the colour is not an essential property.

III. Quantity. More after a good meal. How so? Recall the fact of waste from the work performed by the organs of the body. Infer that there is less after prolonged exertion. Hence the amount varies at different times. Difficult to ascertain. Various estimates are given. Some give it as $\frac{1}{12}$, others as $\frac{1}{1}$, and others as $\frac{1}{8}$ of the weight of the body. The quantity perhaps varies from 8 to 12 quarts.

IV. Parts. When the blood is looked at by the naked eye it seems all alike. Place a drop on a piece of glass and *examine it* by a microscope. It is seen to be a fluid con-

taining some sand-like particles. The fluid is termed plasma or liquor sanguinis, the particles corpuscles.

108.—Blood ; Composition.

The blood is a compound. It is formed of water and solids, and contains gases. In 100 parts, there are 79 of water, 21 of solids. Compare with air.

I. The Liquor Sanguinis. A transparent, nearly colourless fluid. It is composed of serum and fibrin.

1. *Serum.* A fluid, saline and adhesive. If a current of carbonic acid is passed through a diluted portion, a white powdery substance is thrown down. This is globulin. If serum is heated it coagulates. Compare with white of egg. Hence globulin is considered an albuminous substance. If serum is exposed to a very high temperature, so as to decompose the animal matter, salts remain.

2. *Fibrin.* This may be separated from blood by whipping it with twigs. The fibres so obtained are elastic and disposed in striæ. Compare with muscular fibre. Blood in which there is a deficiency of fibrin does not flow so freely through the capillaries. By experiments it has been found that a degree of viscidity is favourable to the flow of a fluid through tubes of a small bore. Fibrin is thus necessary to the viscidity of blood. Its chief office seems to be the reparation of injuries, by the formation of fibrous and connective tissue.

II. *Corpuscles.* These are of two kinds, red and colourless.

1. *Red corpuscles.* In shape, circular disks. Look like little coins, but not flat. Each surface is concave. What then? Thinner in the middle than round their edges. Their size is inconceivably small. The diameter is about $\frac{1}{3200}$ of an inch. How many must be placed in a line to make an inch? How many would it take to cover a square inch? Upwards of 10,000,000. But their thickness is only about $\frac{1}{4}$ of their diameter. How many must be piled to make an inch in height? About 12,000. Then how many would be required to make a cubic inch? More than 120,000,000,000. These red corpuscles flow in the blood through the capillaries. But some of these tubes are finer than the corpuscles. Infer that they are soft, flexible, and elastic. On closer examination they are found to be

or bags. By proper tests the sacs disclose their composition. They are formed of two substances termed globulin and hæmatin. The hæmatin is the colouring matter, and contains *iron*, ¾ of a grain in 1,000 grains of blood.

2. *Colourless corpuscles.* Their size is greater than the red. It would take 2,500 placed in a line to form an inch. There are fewer than the red; about one colourless corpuscle to every 300 red ones. There are more after a meal. Their shape is irregular, and is constantly changing. They have the power of contractility. Consist of sacs, containing a fluid and a nucleus. The nucleus, when set free, becomes a red corpuscle. Have their origin in the lymph.

III. *Gases.* The gases found in the blood are oxygen, carbonic acid, and nitrogen. Oxygen is found more largely in arterial, carbonic acid in venous blood.

109.—Blood: Coagulation.

I. Process. Let a drop of blood be put on a slip of glass and placed under a tumbler that it may not dry up. Examine it after a few minutes. It has lost its fluidity. Invert the glass, it does not fall off. Examine by a microscope. The red corpuscles are found ranging themselves like rolls of coin, the fibrin concretes and forms a fibrous net-work; the serum separates. When blood is drawn in large quantities the same thing goes on. In about 15 minutes it separates into a liquid and a semi-solid. The liquid is the plasma without the fibrin, or the serum. The semi-solid is called the clot. This is coagulation.

II. Clot. What does this consist of? Elicit that it is formed of the corpuscles and the fibrin. State that soon after the blood is drawn the corpuscles sink slowly. What does that show? That they are slightly heavier than the plasma. The fibrin also sinks. What takes place before the fibrin sinks? Elicit that in the circulating fluid the fibrin is in solution, but that when drawn it begins to concrete. State that it sometimes concretes so rapidly that the corpuscles get entangled in its meshes. At other times the corpuscles sink before the fibrin has time to concrete. In this case where will the fibrin be? State that it gives a whitish appearance to the clot. This fibrous covering of the clot is called the buffy coat.

III. ON WHAT COAGULATION DEPENDS. 1. *Fibrin withdrawn.* It may be shown to depend on the presence of the fibrin. Extract the fibrin. How? By whipping it with twigs. What remains? A fluid consisting of the serum and red corpuscles. It is found that this fluid does not coagulate.

2. *Corpuscles withdrawn.* Let the blood of a frog be passed through a filter. The red corpuscles are arrested. The plasma is obtained free. This is found to coagulate. Point out that this experiment does not succeed with human blood, as a filter that allows the fluid to pass cannot arrest the corpuscles.

IV. USE OF COAGULATION. When a finger is cut blood flows. Compare with a waterpipe. Here the water runs out until the pipe is mended by the plumber, or till all the water escapes. Is it so with the cut finger? In a little time the blood ceases to flow. How so? The hole is stopped by the clot. If blood did not coagulate what might happen from merely pricking the finger. Refer to a gaping cut. Does it remain so? How does it get repaired?

110.—BLOOD: USES AND CIRCULATION.

I. FUNCTIONS OF THE BLOOD. 1. *Repair.* Explain that all the tissues of the body are served by blood. Its presence in every part may be clearly shown. Recall that where there is work there is waste. Muscular exertion wastes muscle, brain work wastes nerve, and so on. But it is evident that this waste is replenished. How? It is so from the blood. Each organ extracts from it the material of its own tissue. It has been calculated that upwards of a ton of material is used yearly in building and replenishing the body.

2. *Secretions.* Refer to tears. Their use is to keep the eye washed, the window clean. Where do they come from? They are secreted from the blood. Refer also to saliva, the gastric juice, bile, and the pancreatic fluid. These are all necessary to the process of digestion. Each is secreted from the blood by its own proper organ.

3. *Waste.* In work there is waste. Used up portions of muscle and other tissues are constantly being thrown into the blood. These are burned up in it. The products of

this combustion have to be expelled from the body. What are they? Recall from a previous lesson that they are water, carbonic acid, and urea. To take these from the blood is the office of the skin, the lungs, and the kidneys.

4. *Heat.* Refer to the temperature of the body. Warmth found in every part. Recall the temperature of the blood. What is its average degree? Compare with a warm water apparatus for diffusing heat through a building.

II. CIRCULATION. 1. *Its necessity.* How is the performance of these functions secured? Point out that the blood is evidently undergoing constant change. How? By what is taken from it by the organs, and by the oxidation or burning of what is thrown into it. Infer that it will need replenishing and purifying. Ask for the organs by which the latter is accomplished. The skin, lungs, kidneys. From these and similar facts the necessity of the circulation may be inferred.

2. *Proof.* Refer again to the fact of blood being present in all parts of the body. Pierce the end of the ring finger with a needle, and hold it vertically above the head. The blood oozes out. By what force does this take place? Illustrate the forces that might be thought to account for it if the finger were held down, and show that in this case they cannot act. Refer to the examination of a frog's limb and the perception of the circulation. Refer also to the experiments made on arteries and veins.

3. *Mode.* The blood enters the heart from the lungs a bright red vital fluid. It is propelled by the heart into tubes called arteries. From the arteries it enters very fine tubes called capillaries. Out of these it flows into larger tubes called veins. Its colour in the veins is much darker. By the veins it is carried back to the heart. Before it reaches the heart it receives nutrient material from the organs containing digested food. From the heart it is conveyed to the lungs, where it parts with carbonic acid and water, and receives oxygen. From the lungs it passes back again to the heart to pursue the same course as before. Point out that the distances traversed by the blood being very varied, the circulation is performed in much less time by some portions than by others. Let the children infer that there are two circulations, one through the lungs, the other through all other parts of the body. Give their names, pulmonary and systemic.

111.—The Heart.

I. Description. 1. *Shape and size.* Show a sheep's heart, and get from the children that it is somewhat conical. State that a human heart is about the size of the fist of its owner. That its weight in man is from 10 to 12 ounces, in woman about 2 ounces less.

2. *Position.* In the thorax, nearer to the breast-bone than to the spine. Lodged between the lungs. Its base is turned upwards and backwards towards the spine. Its apex forwards, downwards, and to the left side, between the fifth and sixth rib, and about four inches from the middle line.

II. Structure. 1. *Muscle.* The heart is formed chiefly of muscular tissue. This tissue resembles those of the chief muscles of the body. It is not smooth, but striated. The fibres have no sheath or sarcolemma.

2. *Divisions.* The heart is hollow. It has two sets of chambers, each set distinct in itself, having no direct communication with the adjoining one; and having its own special work. The heart is double. The two divisions of the heart are marked on the outside by a groove extending both back and front, from the base to the apex. In each groove is a small artery by which the heart itself is supplied with blood, for the nourishment of its own walls. Internally the heart is divided by a longitudinal fixed muscular partition called the septum. The right or anterior chamber receives and propels venous blood. It is called the pulmonary division. How so? The left or posterior chamber receives and propels arterial blood. It is called the systemic division.

3. *Auricles and ventricles.* The two great divisions are separated by a transverse movable portion so as to form four chambers or cavities. This division is indicated externally by a little fleshy pendulous appendage. From the slight resemblance of this to an ear, the upper cavities are called auricles; the lower ones are the ventricles. Though the ventricular portion of the heart is much the larger one, yet the cavities have each the same capacity. Each will hold from 4 to 6 cubic inches of water.

The walls of the auricles are much thinner than those of the ventricles. The wall of the left ventricle is much thicker than that of the right ventricle. Why is this?

Recall the work of muscle. Infer that the ventricles have harder work to do than the auricles, and that the work of the left is greater than that of the right.

4. *The valves.* The heart is lined with epithelium. It is called the endocardium. The opening between the auricle and ventricle is strengthened by a fibrous ring. To these rings valves are attached. Formed of the endocardium. The blood flows from the auricle into the ventricle. The valves are to prevent its return. They open into the ventricles. Their loose ends are attached by tendinous cords to muscular projections in the ventricles, termed columnæ carnæ. The contraction of these prevent the valves being forced upward into the auricles. The valve of the right ventricle is formed by three membranes, and is called the tricuspid valve; that of the left is formed by two, and is called the mitral valve.

5. *Pericardium.* A double bag. One half of it invests the heart. It is so arranged as to form a sac, or cavity. This is lined by epithelium, and contains a fluid called the serum. It aids in keeping the heart in its place, as it is fastened to the diaphragm on the right.

112.—The Arteries.

I. Introduction. Artery means air-vessel. How so called? It was given to these tubes when the circulation of the blood was not known, arteries after death containing no blood. The arteries convey blood from the heart. Elicit that they spring from the ventricles.

II. Pulmonary Artery. 1. *Its origin.* This may be gathered from former lessons. In what ventricle does it rise? Of what circulation is it the commencement? What sort of blood does it convey?

2. *Semilunar valves.* The blood is forced by the heart into the artery. How prevent its return? Describe the semilunar valves. Why so called? The valves are pouch-like. There are three. How will they open? As the blood flows from the heart they open into the artery. Similar valves placed in the mouth of the aorta.

3. *Branches.* Point out on the diagram that the artery divides into two branches, one turning sharply to the right. Follow their divisions through the lungs. The tubes divide, and become smaller and smaller until they become con-

nected with the pulmonary capillaries. From these the pulmonary veins receive the blood and convey it to the heart. To which auricle?

III. Systemic Arteries. 1. *The aorta.* From which ventricle does it spring? Point out its course. It rises, curves, descends near the vertebral column till it reaches the loins. Then it sends off branches to the lower limbs.

2. *Branches.* Point out that the main trunk is continually sending off branches which divide and subdivide, the members increasing in number, and diminishing in size as they proceed. Compare with a tree. Hence the system of arteries termed arborescent. The first branches from the aorta are the coronary arteries. They convey blood to the substance of the heart itself. From the arch of the aorta, arteries proceed to the neck and head, called the carotid arteries, and others to the arms called the subclavian. As the aorta descends it sends off numerous branches for the service of important organs. Point out that in this way every part of the body is supplied with blood.

3. *Anastomosis.* State that all the smaller arteries have intercommunication, one artery opening into another of a different branch. This called anastomosis. What is its purpose? Suppose the direct communication to any part cut off. How could it be supplied with blood?

4. *Capacity.* Let the children tell that the blood in the arterial circulation is always flowing from larger into smaller tubes. State that the area of the branches of arteries proceeding upwards, as to the head and neck, is rather greater than the trunks. The latter to the former as 100 to 119. What will be the effect of this? Show that it will tend to diminish the rapidity of the current. Would the same arrangement do for the descending arteries? Why not? Show that it would accelerate the current. Give that the area of the trunk to that of the lower arteries is as 100 to 89. Make clear that the capacity will be as the square of the diameters. Show that a trunk whose diameter was 7 would require two branches, each having a diameter of nearly 5. The square of 7 is 49, and twice the square of 5 is 50.

IV. Arterial Coats. The arteries are formed of three distinct coats, and are of great strength.

1. *Inner coat.* It is thin, colourless, and transparent. It

is exceedingly strong, shown by the fact of its sustaining the pressure of the blood, after the other coats had been removed. State that the inner surface is smooth and polished. Why should it be so?

2. *Middle coat.* This is fibrous and muscular. The muscular fibres are so arranged as to form rings. Recall the mode of contraction of muscular tissue. What will be the effect of contraction on the arterial flow? Show how this will promote the circulation. Point out also how the smaller arteries regulate the flow into the capillaries.

3. *Outer coat.* It is composed of fibrous tissue; whitish, dense, and of great strength. It is remarkably elastic in the direction of its length. What will be the effect of this? Under certain conditions the artery will be lengthened, and then return to its original dimensions.

113.—THE CAPILLARIES.

I. NATURE. 1. *What they are.* The capillaries are a network of fine tubes interposed between the small arteries and the small veins. The connection is not that of a fine tube proceeding direct from one to the other, but of a tube forming loops, and by unions with other tubes, forming meshes as minute as themselves. They are tubes having connections with both arteries and veins. The blood flows from the former through them into the latter. The arteries and veins are in close proximity; yet by reason of the network of capillaries, the distance travelled by the blood from one to the other is comparatively great.

2. *Size.* The term taken from capillus, a hair; but they are very much finer than hairs. The diameter of some is about $\frac{1}{1500}$ of an inch, but of many they are as minute as $\frac{1}{3000}$ of an inch.

3. *Structure.* The walls of the capillaries are formed of delicate membrane. This tissue allows the blood freely to exude through it; and the fluids which bathe the tissues where they are found to enter the blood.

II. OFFICES. 1. *Distribution.* They are found in nearly all parts of the body. So numerous are they in the various tissues, that a pin could not have its point inserted anywhere without rupturing some of them. They form what is called the vascular system: all the tissues which they permeate being termed extra-vascular.

2. The great change from arterial to venous blood is effected in the capillaries. In the arteries the blood is a bright scarlet colour; but if blood were drawn at the same time from a vein of the same part it would be of a purplish hue. The venous blood has less water, less fatty matter, less oxygen, and more carbonic acid than the arterial blood. Thus the blood has parted with some of its constituents in the capillaries, and has received other substances in their place. The change is chiefly in the gaseous constituents. In arterial blood there are 30 per cent. carbonic acid, and 20 per cent. oxygen. In venous blood there are 5 per cent. oxygen, and 35 per cent. carbonic acid.

3. The capillaries not only transmit the blood and receive oxidized products from the tissues, but they are necessary to the great functions of secretion and nutrition. Blood enters the capillaries of the brain, nervous matter is secreted from it, and converted by the brain into an organized portion of its own structure. So with muscle and with other tissues: the special substance of these is secreted from the blood in the capillaries, and is afterwards assimilated by the organ.

114.—The Veins.

I. Description. 1. *Their office.* The veins carry blood to the heart. They have been compared to a reservoir, out of which the "force pump," the heart, receives the fluid that it propels. It has been estimated that three-fourths of the whole quantity of blood are in the veins.

2. *Their course.* They spring like little twigs from the capillaries. Uniting they form larger tubes, and these again larger. These run at intervals into principal veins, which form a sort of canal, of which the others are feeders or affluents. These at length terminate in large trunks by which the blood is conveyed into the heart.

3. *Their walls.* Like the arteries, they are formed of three coats; but not having the same strain on them, they have not so much muscular or fibrous tissue in them. Hence they are much thinner, and readily collapse.

II. Pulmonary Veins. Revise the pulmonary circulation. Where do the pulmonary veins rise? What sort of blood do they convey? To which auricle? Point out on

the diagram the four trunks by which the pulmonary veins are connected with the left auricle.

III. SYSTEMIC VEINS. State that there are two classes of veins—the deepseated and the superficial. This affords the advantage of a double channel for the return of the blood to the heart.

1. *Superficial veins.* They belong to the limbs, and may be seen under the skin. They lie on the fascia of the muscles. They terminate in the deep-seated veins. Of these the saphena may be pointed out on the diagram. It is a good instance of a principal vein receiving many others in its course. Starting from the foot it proceeds up the leg and thigh, bends at the upper part of the thigh, pierces the fascia, and terminates in the deep-seated femoral vein.

2. *Deep-seated veins.* These have a great resemblance in position and course to the arteries. The smaller arteries are attended by two veins, the larger by one. Hence the veins exceed the arteries in number and capacity.

(*a*) *The coronary vein.* This brings the blood that has circulated through the substance of the heart into the right auricle. At its mouth is a very perfect valve. For what purpose?

(*b*) *The superior vena cava.* This enters the upper part of the right auricle. By the inner and outer jugular veins it brings blood from the neck and head; by the subclavian veins from the arms; by the azygos veins, in front of the vertebral column, from the walls of the thorax. It also receives the contents of the thoracic duct at the junction of the left jugular and subclavian veins.

(*c*) *The inferior vena cava.* It enters the lower part of the right auricle. At its mouth there is a sort of valve—the Eustachian. This trunk receives all the blood not conveyed to the heart by the other two trunks. It receives also the blood of the portal circulation. The blood from the stomach, intestines, and some other organs of the abdomen is collected and conveyed to the liver by the portal vein. This vein branches out in the liver like an artery, ending in a capillary network, formed by the fine tubes of the portal vein and of the hepatic artery. From this common capillary mesh-work veins arise and unite into a single trunk with the hepatic vein, which becomes joined to the inferior vena cava.

3. *Anastomosis.* The veins join together more frequently than the arteries. The deep-seated and the superficial have very numerous connections by branches passing from one to the other. With what result? By this means the aim of the double set of veins is secured.

IV. VALVES. The distinguishing feature of the veins. Little pouch-like folds of the lining membrane. Their office to prevent the passage of the blood back to the capillaries. How, then, should they be placed? With their free edges towards the heart. Their presence in the arm made manifest by pressing a vein downwards.

115.—RESPIRATION.

I. CHANGES EFFECTED BY RESPIRATION.

1. *Air.* Give the constituents of air,—oxygen, and nitrogen, and their proportions. Enters the mouth or nostrils. Passes to the lungs. Direct attention to the state of expired air or breath. It has more moisture. Its temperature is higher, between 90° and 100°. Contains much carbonic acid. Above 500 parts of oxygen have been displaced by nearly 500 parts of carbonic dioxide.

2. *Blood.* Draw attention to the pulmonary artery. What sort of blood? Venous; of a dark purplish hue. Contains more carbonic acid and less oxygen than the arterial blood. What sort of blood in the pulmonary veins? Bright scarlet; contains more oxygen and less carbonic acid than the blood in the pulmonary artery. Infer that the change must have taken place in the capillaries.

II. PULMONARY ORGANS.

1. *Windpipe.* Flexible tube, six inches long, formed of cartilage. Upper end opens into the pharynx, into which there are passages for air by the mouth and nose. The opening of the windpipe termed glottis, the upper part the larynx, the part below the larynx the trachea.

2. *Bronchial tubes.* One chief branch to each lung. They divide and subdivide. At length they become very fine hair-like tubes. The larger tubes are formed of cartilage.

3. *The lungs.* Two lungs, the right and left. Each is somewhat conical in shape, having the apex towards the neck. With the heart they nearly fill the cavity of the thorax. Each lung is divided by deep fissures into lobes, of which there are three in the right lung and two in the left.

The lobes are subdivided into lobules, and these into air cells.

4. *Air cells.* To each fine termination of the bronchial tubes an air cell is attached. A little bag, containing little pouches; in each cell 16,000 pouches, all served by one fine tube. Compare with the stem of a pipe placed in the orifice of a bladder.

5. *Capillaries.* On the external coat of each cell is a network of blood capillaries. These are covered by other air cells, and in this way the substance of the lungs is formed. The blood is thus exposed to air on all sides.

III. THE RESPIRATORY MECHANISM.

1. *The thorax.* Recall the description of the ribs and the diaphragm. In how many ways may the cavity of the thorax be enlarged? Suppose the dimensions of the cavity before inspiration to be 6, 8, and 10 inches, and that inspiration increased each dimension by 2 inches, what effect would that have on the cavity? It would double its capacity.

2. *The Diaphragm.* Describe its action. To what due? With what effect?

3. *The ribs.* Point out how the intercostal muscles are attached, and explain their action in increasing the capacity of the thorax.

116.—INSALIVATION AND DEGLUTITION.

I. INTRODUCTION. Examine on work and waste. How is the waste renewed? What enters the system? In what form? Refer to the several tissues of the body. Infer that food passes through changes before it is fitted to serve these. Give general description of the alimentary canal.

II. INSALIVATION.

1. *The mouth.* The primary receptacle of food. A cavity having a moveable floor formed of the lower jaw and tongue, and a fixed roof, the hard palate. Has its front and lateral margins studded with teeth.

2. *The teeth.* Recall facts formerly given. First set of teeth, how many? When replaced? Ultimate number? The kinds of teeth, incisors, canine, bicuspid, and molar. The number and office of each. Point out that man by his modes of cooking and use of instruments aids the incisors

and canines. Describe the surfaces of the molars. Uneven, the upper ones unlike the lower ones. Infer the advantage of this for grinding the food. Give the constituents of the teeth. The pulp cavity with its blood vessels and nerves, the dentine, cement or bony matter, and the casing of enamel. State that enamel once destroyed cannot be renewed; hence the necessity of caring for the teeth. How?

3. *Mastication.* Point out that the fixed upper jaw has a larger curve than the lower one, so that the upper teeth somewhat overlap the lower ones. With what effect? Elicit that the lower jaw is capable of two motions, so that we may chop like a dog and grind like a cow. What is the effect of these actions on the food? To bruise and break it down into minute portions.

4. *The tongue.* Elicit that the tongue is actively at work during the process of grinding. It turns the food over, it collects it from different parts of the mouth, and places it between the teeth. Admirably adapted by its muscles for motion in every direction.

5. *Salivary glands.* Refer to the "mouth watering" at the sight of food. What is it? Saliva. Its office to prepare the food for swallowing, and to change some portions of the food into nutrient material. It converts starch into sugar. When food is being eaten a large quantity is poured into the mouth. For instance, a dry crust chewed well becomes a very moist pulp. Where does the saliva come from? Point out the positions of the three pairs of glands. Those in front of the ears, called parotids; under the jaw, submaxillary; under the tongue, sublingual.

III. DEGLUTITION. What is it? The passage of the food from the cavity of the mouth into that of the pharynx, thence by the gullet into the stomach.

1. *Velum or curtain.* Recall the facts about the pharynx. What openings are there into its upper part? How prevent food entering into these openings? Describe the curtain formed by the soft palate and uvula. Its action that of a double valve. When down it completely closes the cavity of the mouth from that of the pharynx; when raised at the act of swallowing it completely separates the upper from the lower part of the pharynx.

2. *Epiglottis.* Ask for the facts about the windpipe. If food entered the glottis, what would result? Describe the

epiglottis. Point out that the act of swallowing presses the epiglottis down so as completely to cover the glottis.

3. *Pharynx.* Explain the necessity of the act of swallowing being rapid. Show that it is the result of several contrivances. Try to give clear conceptions of the several actions. The raising of the lower jaw, actions of the tongue, drawing upwards and forwards of the larynx beneath the root of the tongue, the raising of the pharynx, and the action of its muscles by which the bolus is grasped and passed onwards.

4. *Œsophagus.* Show that the passage of food is not due to gravity. Persons can swallow when lying down. A person also standing on his head can swallow. Describe its action. It is termed vermicular. How so?

117.—Digestion.

I. Stomach.

1. *Description.* A somewhat oval bag, soft and fleshy. The larger end towards the left side, the smaller end stretching obliquely across the abdomen. It has two openings, the cardiac and the pyloric. The flap which hangs from the stomach is called the omentum.

2. *Coats.* It has three coats. The external one is serous, the second muscular, and the inner one mucous. The latter one is thickly studded with minute pepsin glands, by which the gastric juice is thrown out. A piece of tripe may be used to illustrate these coats.

3. *Gastric juice.* Prepared in the glands of the mucous coat. A powerful fluid capable of dissolving all kinds of food. It is formed of water, hydrochloric acid, lactic acid, and the ferment pepsin. It is poured out as needed. Food excites the stomach to action. When the wants of the system are satisfied, gastric juice ceases to flow. Hence, too much food will produce indigestion.

4. *Chyme.* Food received into the stomach is moved about by the contractions of the muscular coat. It is thus exposed to the action of the gastric juice. In this way it is formed into a semi-fluid called chyme. During this process, matters that have been completely dissolved and fluids are absorbed by the blood-vessels, and thus carried to the venæ portæ. As the chyme is completed it passes through the pyloric orifice into the duodenum.

II. THE INTESTINES. 1. *Divisions.* Give their length. About six times that of the body. Their divisions into the small and large intestines. Point out that for convenience of description the small intestines have been divided into duodenum, jejunum, and ileum. In the first the digestive process is completed, and in the latter the nutrient matters are absorbed. The office of the large is to expel the excrementitious portion of the food.

2. *Duodenum.* So called because of its length: about twelve inches. It has been called a second stomach because here the chyme is converted into chyle. Point out how this process is effected. A mucous fluid having solvent properties is secreted by its own glands. From the biliary duct it receives bile, and from the pancreas a fluid very much resembling saliva.

3. *Chyle.* A milky fluid, in some respects resembling the blood. It contains albumen, fibrin, fatty matters, and a trace of iron. Like blood it coagulates, and separates into serum and clot.

4. *Absorption.* When the chyle is formed it has to be absorbed. This is done by passing it into the jejunum and ileum.

(*a*) *Jejunum and ileum.* Form a very long tube, so that the chyle comes in contact with a large surface. The first portion of this tube is called jejunum (*jejunus*, hungry), as here the absorbing process is somewhat rapid. The second portion is termed ileum because of its small folds.

(*b*) *Villi and lacteals.* Show a diagram of these. The former absorb the nutrient matter, the latter convey it to the thoracic duct.

118.—THE LIVER.

I. SIZE. The largest gland in the body. Colour reddish brown and yellow, weight nearly four pounds. Its length from right to left about thirteen inches, from back to front about seven inches.

II. SHAPE. Upper surface convex, lower one irregularly concave. Thick behind and at the right side, thinner in front, hence somewhat of a wedge shape. It is divided into a right and a left lobe, of which the right is the larger. This division is effected by a broad ligament, formed by a fold of the peritoneum. This ligament is

attached to the diaphragm above. Its free edge is called the round ligament, and is an obliterated vein. On the under surface, chiefly in the right lobe, there is another furrow or fissure, at right angles to the lobal division. It is termed the porta. Through it the artery, vein, and nerves enter, and the bile duct passes out. This fissure is a gateway to a system of canals, branching off from the main one, called the portal canals.

III. Position. Immediately under the diaphragm. It stretches across from the back to the front of the abdomen. Point out the positions of the abdominal aorta and inferior vena cava. On the right the liver touches the kidney, a little more forward the colon, and more to the left it is in contact with the pyloric extremity of the stomach. It may be felt under the right ribs, especially if enlarged.

IV. Coverings. 1. *Peritoneum.* Partially invested by it. In some places this is reflected either to fix it or to support the artery, veins, and nerves. Point out how the liver is attached to the diaphragm by the broad, coronary, and lateral ligaments. With what result? It will partake in its motions.

2. *Fibrous coat.* Invests every part of its surface. Lines the portal canals with a loose web of areolar and elastic tissue.

V. Its Substance. 1. *Lobules.* Describe one. A polyhedral figure, about $\frac{1}{10}$ of an inch in diameter. Compare with millet seed. Each lobule a perfect gland in itself. The interior filled with the capillary network, which is served with blood by a branch of the portal vein. This blood passes by a minute veinlet through the base of the lobule into a branch of the hepatic vein. Compare with a leaf attached to the twig of a tree.

2. *Liver cells.* Placed in the meshes of the capillary network, $\frac{1}{1000}$ of an inch in diameter. Contain a nucleus, and granules of fatty matter. Source of the secretive power of the liver. Minute canals between them connected with branches of the hepatic duct.

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